The Engineer

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THE ENGINEER

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PROGRESS REPORT ON NUCLEAR POWER

The second annual report of the United Kingdom Atomic Energy Authority, which was issued last week, covers the period April 1, 1955, to March 31, 1956. As pointed out in the first paragraph of the report, the dominant feature of the twelvemonth period was the great increase of interest and activity throughout the world in the development of power from nuclear energy for peaceful purposes. This interest was stimulated by the removal of security restrictions by the United Kingdom, Canada and the U.S.A. on most of the nuclear energy information relating to reactors, and it was brought sharply to a focus by the Geneva Conference on the Peaceful Uses of Atomic Energy last summer. At home the Authority's own construction of reactors is proceeding as planned and the nuclear power programme has been pursued with considerable drive and energy. The four industrial groups concerned are due to submit tenders for the Stage 1 reactors to the Central Electricity Authority in October of this year, and the report confidently anticipates that the designs for these first nuclear power stations will already show a substantial technological advance on the Calder Hall prototype. The weapons programme, particularly the development of thermo-nuclear weapons, has continued to have high priority, and it is reported that the Weapons Group actually showed a higher rate of increase of staff than other parts of the Authority. This Group, in future, will also take an interest in nuclear reactor development, as it will have responsibility for research into, and development of, reactors for military applications. The Authority has also had to face a considerable and unexpected expansion in its own construction programme during this period due to an increased requirement for supplies of military plutonium. To assist the Authority's staff in meeting this demand, Messrs. Merz and McLellan are being employed as consulting engineers for part, and as construction agents for the whole, of the work at Chapel Cross, Annan, where two units of the Calder Hall type are now being built. At Harwell new types of reactors are being studied, together with all the associated problems of metallurgy, chemical processing, and waste disposal, work which will be assisted considerably when the materials testing reactors, now being built at Harwell and Dounreay, become available. Research is also being carried out on the possibilities of obtaining economic power from controlled thermo-nuclear reactions, but the report indicates that many problems have yet to be solved before this can become reality.

These are some of the activities of the United Kingdom Atomic Energy Authority with which most people are already familiar, for they have been frequently reported in the daily Press. It must not, however, be overlooked that the enormous increase in interest in the immediate possibilities of nuclear power, and the consequent urgency for adequate research, development and design work in this field, is not the only expansion that the Authority is having to face. The Authority is already a large industrial undertaking which is expanding steadily. In fact, it is a process industry with fixed assets worth over £110 million which produces fissile material. The production of radio isotopes, almost a by-product of the industry, also continues to grow, and the total value of the products sold during the year reached approximately £483,000. Some of the less spectacular problems the Authority has consequently had to deal with are those of accounting and administration. For example, the report points out that the Authority has had to face a major task in establishing commercial accounting systems throughout the organisation, as accounting at some of the establishments prior to formation of the Authority had been aligned primarily to vote accounting. The recruitment of suitable staff, which featured so prominently in the Authority's first report last year, continues to be a major problem, and the figures quoted, i.e. 52,000 applications received for non-industrial posts and 12,000 candidates

interviewed, is a formidable record indeed. Noting the fact that during this same period the total of non-industrial staff rose from 8302 to 10,795, it would seem that only about 1 in 20 of those applying for posts with the Authority is suitable or chooses to accept an offer. No doubt, though in the future many more scientists and technologists are likely to consider nuclear energy as the field in which they can make for themselves an interesting and worthwhile career, the Authority is unlikely to find its recruitment problem easier, as private industry will also have an ever-increasing need of such people.

The report shows that the Authority has made considerable progress towards establishing sound foundations for nuclear power development in this country in a world climate of rapid change. It is probably fortunate for the country that the Authority was formed two years ago and thus has had some opportunity to organise itself to meet the quickening tempo of nuclear energy developments. The methods of training and collaborating with the four industrial groups that are designing the Stage 1 reactors for the power programme seem to have worked well, and could set a pattern for the future. The Authority has also set up a panel with representatives of the electricity undertakings to consider the problem of reactor siting, and the health and safety aspects of the industry are continuously under review. So far, so good. In many ways the past year has been historic, for it can be said to be the year in which the immediate possibilities of nuclear power came to be accepted. Before the end of 1956 we in this country will have in operation our first nuclear reactor supplying power to the C.E.A., and industry will be playing a major part in the construction of the first nuclear stations. The inevitable question that then arises is — does the set-up that has now become firmly established in this country appear adequate to exploit the next stage of development? We think that it does, provided that the Atomic Energy Authority maintains, and is allowed to maintain, real flexibility in its approach to new projects and to the place these may occupy in a reactor programme either at home or abroad. The report describes several reactor systems that are now being considered at Harwell. There are certain to be others in the future. Not all will be projects that have consequences as far-reaching as the development of the gas-cooled, graphite-moderated thermal reactor, but each may well have its place in an overall system for the utilisation of fissile material. It is, in fact, imperative that, having embarked on an imaginative plan for the development of nuclear power in this country, we should not sit back on this and fail to keep this plan constantly under review. Developments are rapid and we must be prepared to reconsider our ideas, not only in the light of our own needs, but also in the light of the needs of other countries.

ASWAN AND SUEZ

It is sad for engineers to have to confess to it, but they are probably responsible for more troubles in this world than the members of any other profession! In the last 150 years—far too short a time in relation to the adaptability of human nature—they have wrought an enormous change in man's circumstances. In every developed country the inhabitants as a whole have become immensely richer than men have ever been before in the history of the world. The naive might expect in such circumstances that men would be more content. In reality great social stresses have been created within every nation's borders as the attempt is made to bring social behaviours and individual beliefs and prejudices into line with the new conditions. International stresses are created too. For when, for example, by an engineering achievement, immense power is developed from the natural resources of a region which has not the industry to absorb it, other, more fully developed regions acquire an interest, possibly a vital interest, in at least the peace and more probably the prosperity of the region in which the facility lies. By consequence patriotisms may be aroused or questions of sovereignty posed. Even if the two regions are subordinate to a single overall Government, local passions may be stirred. The people of the Scottish Highlands stood, in fact, to benefit rather than the reverse from the export of Highland water power to the Lowlands. That fact did not prevent the generation of a narrow parochial opposition to the development of the water power. But a much more complicated situation arises when more than one sovereign government is involved. The attention of everyone now, for example, is directed towards Egypt. The Egyptians had set their hearts on the building of a high dam at Aswan. No doubt that dam would have benefited the Egyptian people. But many engineers, informed about the Nile, felt very dubious whether in relation to the development of the whole Nile valley for the ultimate benefit of all its riparian inhabitants that high dam was as good a proposition as several other projects. Those projects might indeed have benefited Egypt less but would have benefited other countries more.

The decision of western politicians that financial support should be offered for the high dam seems to have been based not solely upon technological considerations, but upon other grounds as well. But in our view technological problems can only be satisfactorily solved on their technological merits. If other considerations, such as nationalism, are allowed to intrude not only will the ultimate benefits to be expected be reduced, but there will be laid up for the future further and worse nationalistic troubles. The passionately nationalistic Egyptian reaction to the sudden withdrawal of financial support for the Aswan dam affects yet another of the contributions that engineers have made to the enrichment of the world. The claim to have "nationalised" the Suez Canal implies that henceforth Egypt shall have the sole right to decide what traffics will flow through it, what dues the traffic shall pay and how well or ill the canal shall be maintained. Were it a prime interest of Egypt that the canal should be open to all traffics and fully maintained the world might be content to let matters rest. But in fact the Suez Canal is a facility of far greater importance to other nations than to Egypt just as Scottish water power is of greater importance to the Scottish Lowlands than to the Highlands. Who would contemplate putting the responsibility for the operation of a Highland power station solely in the hands of the local crofters? By building the canal engineers benefited, not Egypt alone, but the peoples of a high proportion of the world's countries. It must seem to engineers, as technologists, that those best fitted to control and to operate any technological device are those most interested to see that it functions efficiently; and that the world will benefit best from the device if it is so operated. But that, it will be observed, is a proposition that has no relation whatever to nationalism.

As we remarked in these columns only a few weeks ago, narrow and jealous claims to sovereignty, whether by a nation or a council round a parish pump, frequently stand in the way to prevent or to delay the execution of engineering projects which engineers can see will bring benefits to all. It is now made apparent that similarly mistaken claims can affect the efficiency with which the products of engineering skill are operated. What is at issue in Egypt is the problem of the control of the Suez Canal. A somewhat similar question was posed quite recently in this country when the socialists maintained that the nation could not trust private companies to operate basic industries for the national benefit. Given that the lack of trust was justified—a point open to dispute in that instance!—the solution found was that of bringing ultimate control into the hands of the nation as a whole. The corresponding action relating to the Suez Canal clearly lies in its internationalisation. But oh! how much indignant nationalism, what passionate claims that sovereignty is insulted, are likely to stand in the way of doing something which, to engineers, who built the canal and who are solely concerned that their beneficent gift to mankind should be effectively utilised, must seem just commonsense.

A Seven Day Journal

Agricultural Engineering

On Wednesday and Thursday last week the British Society for Research in Agricultural Engineering opened to visitors the National Institute of Agricultural Engineering at Wrest Park, Silsoe. Much of the work displayed was of general engineering interest: the tractor with hydrostatic transmission, subject of a recent paper (The Engineer, April 27, 1956) was on show, and further developments are in hand. Hydraulic transmission would allow the wheels to be tilted when the vehicle was working across a slope, thus increasing stability, and facilitate four-wheel drive, with increases in traction efficiency and maximum tractive effort. New and higher speed pumps for the tractor were on show and under test. This tractor opens the possibility of row-crop working with tools mounted amidships under the driver's observation and control, and research has commenced on such vehicles. Continental work on the human engineering of the driver's position was presented, showing, for instance, that the slightly raked steering column common to commercial vehicles allows a high torque but a minimum angular velocity to be applied by the driver. To allow existing results, showing a decreased accuracy of course-holding with higher geared steering, to be extended to higher ground speeds, a rear-engined research tractor with a three-speed gearbox in the steering gear has been made. This tractor is an example of the ingenuity in adaptation exercised at the Institute, being largely composed of 10 cwt "Thames" components. Another example is a high torque dynamometer, power being fed into one axle shaft of an erstwhile tractor transmission and dissipated by four dynamos driven off the clutch shaft. The entire casing swings about the hub bearings for torque measurement. "Treadmill" and belt dynamometers were also in evidence, and hot or dusty environments could be provided for tractor testing. An important part of the Institute's work is the conduct of prolonged representative farm trials of tractors and agricultural machinery, excluding dairy machinery. The full trials reports detail the conditions and results of each test and the performance and deterioration of individual machines: a series of abridged reports has now been commenced, which will give those findings valuable to the farmer in compact form. The Open Days offered an opportunity to see much unfamiliar equipment, including German and Czechoslovakian tractors. United States plant, distinguished by double-acting hydraulic rams, included a Minn-Kota rock picker of impressive proportions and an Eversman automatic land leveller. The ingenious linkage used by the latter was demonstrated by a working model, and another model, simulated the process of down-the-row thinning.

Road Research in 1955

The D.S.I.R.'s annual report on road research has been published this week. As usual, the Director's report is divided into the two divisions of "Traffic and Safety" and "Materials and Methods of Construction," and there is an introductory report by the Road Research Board. The studies which have been in progress are of great interest and include traffic research on the effect of the proposed London-Midland motorway, and on the capacity of a large roundabout, and subjects such as the behaviour of vehicles when braking in an emergency (a device which prevents wheel locking under heavy braking has been tested), and on skidding resistance in relation to road layout and traffic. An experimental road has been built in which seven different concrete mixes were laid, having a range of compressive and flexural strengths, and tests on it are expected to demonstrate the practical importance of high flexural strength in concrete slabs. Apart from those detailed studies, however, the report is of special note because of the general criticisms made by the Board. The current programme of road construction in this country is out of scale with the needs, it is stated, and has no hope of even keeping pace with the increase in the number of licensed vehicles. The increase in the amount of traffic on the roads between 1954–55 was double the increase in the previous year. The question of providing a more scientific basis for the national road programme was considered by the Board's committee on economics, which recommended that the government departments concerned should consider what new organisation or expansion of existing organisation was required to meet the situation. However, it was emphasised that the present programme of road building should not be delayed to await further studies of national needs. The Board expressed concern at the defective state of many of the vehicles on our roads; the evidence of that was growing in volume. Information obtained by the Laboratory in carefully conducted surveys was reinforced by results from the Slough vehicle inspection centre and from the "pilot" vehicle testing station at Hendon. The Board stated that it had come to the conclusion that a compulsory system of inspection was essential in the interest of all road users.

The Engineer
100 Years Ago
(AUGUST 1, 1856)

"Unequal Railway Tariffs"

"We have, more than once, we believe, expressed our conviction that a slight general increase upon the present rates of goods traffic, would not in the remotest degree affect anybody in the world except the railway shareholders, and for them certainly such a procedure would be one of the greatest boons which could well be imagined. We have not made a calculation, but it is easy to believe that an advance of five per cent on present rates would yield a very considerable aggregate for the exchequer of any one of the great companies.

"It certainly seems anomalous that goods should be carried at a rate so low in proportion to that at which the passenger traffic is conducted. The great expense of staff, warehouses, delivery, is altogether a necessity attendant upon the goods traffic, and should be paid for, not by the shareholders, but the consumers. But if no alteration is to be made, surely we have a right to demand that the existing rates shall be adhered to without variation, and that no partiality shall be shown to one over another. Traders should all be treated alike, and no unfair advantage should be given by carrying the goods of one individual at a lower rate than that charged to another. It is easy to see how, by the adoption of varying rates, one man may be enabled to undersell his competitor; and it is not seemly that a railway company should make itself the instrument to such an illegitimate result. Let every manufacturer and tradesman have an equal position, and be placed, at all events in this respect, at equal advantage."

Surplus Refinery Gas

According to a statement issued by the Southern Gas Board, a ten-year agreement has been concluded by the Esso Petroleum Company, Ltd., with the board, for the supply of surplus gas from the Fawley refinery for use by households and industry in the district. Such a use for refinery gases was proposed two years before the refinery came on stream in 1951 and since then the examination of the technical aspects of the project has continued, together with a study of economic conditions. During this period of time the pattern of future demand for petroleum products has become clarified, as has also the position with regard to the new gas-making techniques, so that commercial information was available upon which to base a suitable agreement. By this about 17,000,000 therms a year of refinery gas will be supplied to the board and, after reforming at Southampton, will give the equivalent of about 13,000,000 therms of town's gas each year. As a result it is expected that an annual saving of 115,000 tons of coal will be effected, with a corresponding reduction of only 20,000 tons in the amount of coke available, and a saving in the amount of gas oil and heavy oil now used in water gas manufacture. The amount of gas involved in the contract is about 5,750,000 cubic feet per day, of 870 B.Th.U. per cubic foot calorific value, or the equivalent of 50,000 therms per day. A 15in cast iron main, 17 miles long, will convey the gas from Fawley to the Southampton gas works, where it will be reformed in a water gas plant by changing the constituents of refinery gas by chemical means into those normally present in town's gas.

Professor T. B. Abell, O.B.E.

It is with regret that we record the death, last week at his home in Devonshire, of Professor T. B. Abell, who retired from the Alexander Elder Chair of Naval Architecture at Liverpool University in 1940. He was in his seventy-seventh year, being born in March, 1880. After completing his early education at the West Buckland School he went to the Royal Naval College, Keyham, for five years, and afterwards, from 1900 to 1903, studied at the Royal Naval College, Greenwich; he then was appointed a member of the Royal Corps of Naval Constructors. During the next few years he was employed at the Admiralty Experimental Works, Haslar, and, after serving two years under the Director of Naval Construction, became an instructor in naval architecture at the Royal Naval College in 1910 and senior instructor in 1912. In 1914 he became professor of naval architecture at Liverpool University, of which he was appointed Pro-Vice-Chancellor in 1935, and had the title of Professor Emeritus conferred upon him when he retired five years later. He returned to the Admiralty during the first world war as a constructor and afterwards as Assistant Director of Designs to the Admiralty and Ministry of Shipping. Until his retirement in 1940 he was a member of the Institution of Naval Architects, of which he was made a vice-president in 1933, and he was the author of a number of technical papers, one of which gained the Institution's Premium Award in 1911, while another was awarded the Gold Medal in 1916.

Modern Dewatering Methods in Irrigation Problems

By S. LELIAVSKY, Ph.D., M.I.C.E., M.Am.Soc.C.E.

No. II—(*Concluded from page* 116, *July* 27*th*)

The well-point type of enclosure dewatering has nowadays become standard routine in building foundations of hydraulic works in the channels of alluvial rivers. One of the characteristic differences between this modern type and the earlier system of open pumping, consists in that the capacity of the latter is fairly elastic and can be supplemented in the course of the work by additional units, without causing much trouble ; whereas the extension of the capacity of a well-point layout may possibly constitute a much more difficult problem. Many rules and formulas have therefore been produced, permitting the calculation of a well-point scheme beforehand. They are briefly reviewed in the following article. Practical hints bearing on the choice of the system according to the local conditions of each particular case, are given at the end of the article.

(*f*) Case When the Effective Depth is Less Than Thickness of Permeable Layer

THE next point to be considered is the depth of the well, h_1, as compared to the depth, H, of the permeable strata. In practical applications H and h_1 are frequently assumed equal. Still, the designer must be capable of estimating, at least approximately, what may be the error consequent on such an assumption. Experiments to elucidate this point were carried out by Forchheimer.[11]

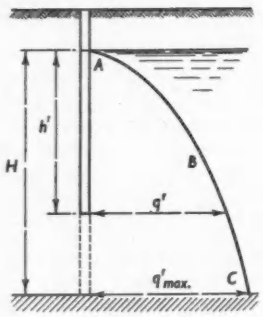


Fig. 9

With reference to Fig. 9, let q' be the discharge of a well of depth h', the depth of the permeable layer being H. The maximum value of q' will then be q_{max} when $h'=H$.

For intermediate values of h' Forchheimer finds that the curve ABC lies between an ellipse and a parabola. This yields

$$\frac{q'}{q'_{max}}=\sqrt{\frac{h'}{H}}\times\sqrt[4]{\frac{2H-h'}{H}}.$$

If, now, we compare two wells A and B (see Fig. 10), one of which reaches down to

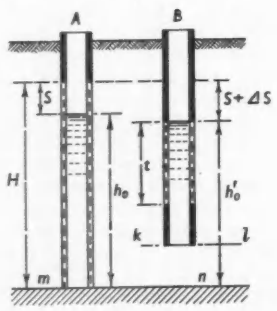


Fig. 10

the impermeable stratum mn, whilst the other stops at the level kl and is provided with a limited effective filter depth t only, we will then find that in order to give the same discharge the water surface in the second well must be reduced to a lower level than in the first well, namely, with the notation shown in the figure, we will have either

$$\frac{H^2-(h_0')^2}{H^2-h_0^2}=\sqrt{\frac{h_0'}{t}}\times\sqrt[4]{\frac{h_0'}{2h_0'-t}}$$

or

$$\frac{H^2-(h_0')^2}{H^2-h_0^2}=\sqrt{\frac{h_0'}{t+0\cdot5r_0}}\times\sqrt[4]{\frac{h_0'}{2h_0'-t}}$$

depending upon whether the bottom of the pipe is closed or open.

(*g*) Groups of Well-Points

Dewatering systems, as a rule, comprise a certain number (sometimes quite a large number) of wells ; in fact, single-well systems are nowadays not used at all. Comparative calculations show that, whilst the discharge and the dewatered area are nearly the same in both cases, the lift on the pump for a single well is greater than for a system consisting of several wells. This means that the required horsepower is less in the second case. Our next problem therefore concerns the combined effect of several wells, working together.

The solution of this problem given by Forchheimer in 1886[12] has withstood the test of time, and is still used by the majority of authors dealing with the subject, e.g., Schoklitsch,[13] Sichardt,[14] Forchheimer himself,[15] and others. It will be remembered, in this connection that Thiem's formula

$$z^2-h^2=\frac{q}{\pi\alpha}(lg_e x-lg_e r),$$

supplies one of the solutions of Forchheimer's general formula,

$$\frac{\partial^2(h^2)}{\partial x^2}+\frac{\partial^2(h^2)}{\partial y^2}=0,$$

and that the sum of several such solutions is a solution in itself.

In the case of a group of wells we can write for each of them

$$z^2=f_1(x,y)$$
$$z^2=f_2(x,y).$$
$$\cdots\cdots$$

The underground water surface representing the cumulative effect of these various influences will then be

$$z^2=f_1(x,y)\pm f_2(x,y)\pm \quad . \quad . \quad . \quad (4)$$

for it can easily be shown that this combined function is indeed a solution of Laplace's equation.

Consider, now, several well-points at

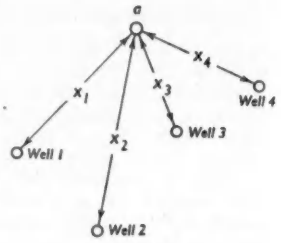


Fig. 11

various distances $x_1, x_2, x_3 \ldots$ from a certain point a (see Fig. 11). Let

$h_1, h_2, h_3 \ldots$ be the heights of the water columns in these wells,
$r_1, r_2, r_3 \ldots$ be the radii of the wells,
$q_1, q_2, q_3 \ldots$ be the respective discharges,
$z \ldots\ldots\ldots$ be the height of the water column in the point a
$n \ldots\ldots\ldots$ be the number of wells,
$h_0 \ldots\ldots\ldots$ be a constant.

For every well we can then write (see equation (1)) :

$$(z^2-h_1^2)=\frac{q_1}{\pi\alpha}(lg_e x_1-lg_e r_1)$$

$$(z^2-h_2^2)=\frac{q_2}{\pi\alpha}(lg_e x_2-lg_e r_2)\ldots\ldots\ldots$$

Substituting this in (4),

$$(z^2-h_0^2)=\frac{q_1}{\pi\alpha}(lg_e x_1-lg_e r_1)+\frac{q_2}{\pi\alpha}(lg_e x_2-lg_e r_2)\ldots.$$
$$+\frac{q_n}{\pi\alpha}(lg_e x_n-lg_e r_n).$$

It most often occurs that the diameters and discharging capacities of a group of wells belonging to the same system are the same, i.e. $r_1=r_2=r_3 \ldots =r_n$, and $q_1=q_2=q_3 \ldots q_n$. This gives

$$(z^2-h_0^2)=\frac{nq}{\pi\alpha}\left[\frac{1}{n}lg_e(x_1\times x_2\times x_3 \ldots \times x_n)-lg_e r\right]$$
$$\cdots\cdots \quad (5)$$

It remains to find the value of h_0. With this object in view we imagine all the wells shifted to one single point, the discharge of this hypothetical central well being equal to the sum of the discharges of all the wells taken together, namely,

$$Q=q_1+q_2+\ldots q_n.$$

Equation (5) changes, then, into

$$z^2-h^2=\frac{Q}{\pi\alpha}(lg_e x-lg_e r) \quad . \quad . \quad . \quad (6)$$

Suppose now that the individual wells are brought back into their original positions, while the total discharge Q remains always the same. This will cause local alterations of the depressed water table, but the general form of the latter, such as observed from a certain distance (infinity ?), will remain substantially the same.

This means that h_0 may approximately be assumed to be the water depth in an imaginary well discharging the same amount of water as the system of wells under consideration.

(*h*) Circular and Rectangular Layouts

We shall first consider a circular layout of a group of wells, as shown in plan in Fig. 12. In applying formula (5) we will then find that in this case, all the distances x are equal to the radius A. Thus

$$(z^2-h^2)=\frac{Q}{\pi\alpha}(lg_e A-lg_e r) \quad . \quad . \quad . \quad (7)$$

[11] Forchheimer, "Grundwasserspiegel bei Brunnenanlagen."

[12] Zeitschr. d. Archit.-u. Ingen. Ver. zu Hannover, 32 (1886), page 547.

[13] *Der Wasserbau*, 1st. Ed., Vol. I, page 178.

[14] *Grundwasserabsenkung* . . ., page 49.

[15] *Hydraulik*, page 450.

In this formula $Q=nq$ is the sum of the discharges of all the wells. The depth h is found from

$$h^2=H^2-\frac{Q}{\pi\alpha}(lg_e R-lg_e r).$$

Thus,

$$(H^2-z^2)=\frac{Q}{\pi\alpha}(lg_e R-lg_e A).$$

The z value appearing in this formula is supposed to be measured in the centre 0 of the system. The discharge Q is found from

$$Q=(H^2-z^2)\frac{\pi\alpha}{lg_e R-lg_e A}.$$

Thus, if the required drawdown $s=H-z$ is known, Q can be calculated, and the

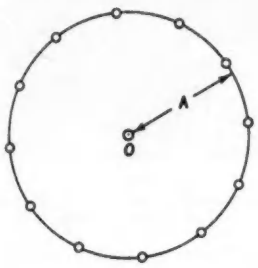


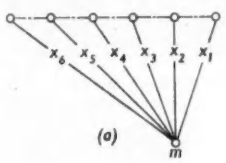
Fig. 12

number n of wells of given yield, $q=Q/n$, determined. The radius A will then depend on the area to be dewatered. Note that, according to Sichardt (loc. cit.) it must not be less than

$$A_{min}=\frac{n\times b_{min}}{2\pi},$$

in which b_{min} is the minimum spacing calculated by the author's formula (see earlier).

The circular layout is only seldom used at present. The rectangular arrangement of wells is the one generally adopted. It may either consist of one or several parallel rows of wells (Fig. 13*a*), or may alternatively take



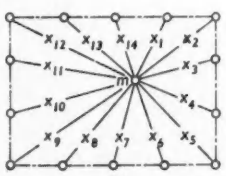


Fig. 13

the shape of a closed or open rectangle (Fig. 13*b*).

The main point of the calculation will then be to find the value of the Naperian logarithm of the product

$$\Pi(x_n)=x_1\times x_2\times x_3\ldots\times x_n,$$

which appears in equation (5).

$$(z^2-h^2)=\frac{Q}{\pi\alpha}\left[\frac{1}{n}lg_e\Pi(x_n)-lg_e r\right].$$

The same product is also included in the formula

$$(H^2-z^2)=\frac{Q}{\pi\alpha}\left[lg_e R-\frac{1}{n}lg_e\Pi(x_n)\right] \quad . \quad (10)$$

and is therefore the characteristic coefficient for a given system of wells.

The drawdown—that is, the difference between the natural water table and the ground-water level as lowered by the well-point system—can be found for each point m from the equation :

$$s=H-\sqrt{H^2-\frac{Q}{\pi\alpha}\left[lg_e R-\frac{1}{n}lg_e\Pi(x_n)\right]}.$$

In these formulæ all values are constant except s, z and Π (x_n). Thus, s and z can be determined for the point m, depending on the local value of the product Π (x_n). It is therefore clear that the ground water surface is a "field" depending on this product.

The distances x_1 x_2, &c., are measured from the centres of the wells, which means that at every such centre the value of the product is zero, and the corresponding logarithm is $-\infty$. Hence, such centres are singular points, characterised by interruptions of continuity of the relevant mathematical function. This, however, does not constitute an unsurmountable difficulty, in so far as practical calculations are concerned, for it is evident that the seepage formulæ based on the potential theory cease to be applicable in the interior of the pipes. Hence, the minimum possible value of x to be inserted in the relevant equation is not zero, but r_0. It follows that by putting $x_1=r_0$ and all other values of x, as calculated from the drawing, we obtain the water level in the well itself.

Looking at this problem from another stand-point, it will be observed that for relatively high filtering velocities d'Arcy's coefficient ceases to remain constant, and therefore, in practice, the formulas developed in the foregoing paragraphs do not apply in too close a vicinity to the well.

(*i*) Dewatering Schemes Near a River

It has, so far, been assumed that the supply of percolating water from all sides of the well was uniform. This may indeed be the case for wells placed far away from natural watercourses, but in building barrages, and other diversion works, as well as bridges, quays, &c., the foundations are always laid in close

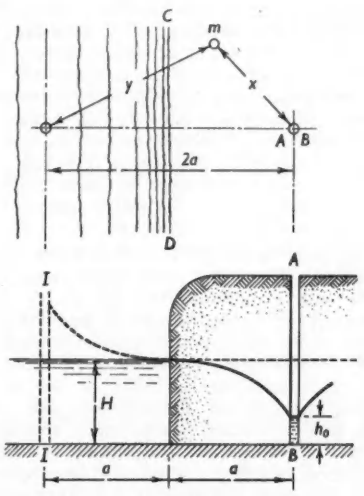


Fig. 14

proximity to a more or less important river, and this must naturally cause an unsymmetrical ground water supply—a consideration which cannot be overlooked in planning the dewatering net. To solve the problem, Forchheimer[16] places an imaginary well, *I–I* (see Fig. 14) at the same distance a from the bank as the real well *AB*, the effect of which is required to be investigated. The two wells then form a symmetrical system, for the imaginary well is supposed to be supplied with the same discharge as is drawn from the real well.

For a point m (see same figure) which is the apex of a triangle with x and y as sides, and $2a$ as base,

$$z^2-H^2=\frac{q}{\pi\alpha}[(lg_e x-lg_e r_0)-(lg_e y-lg_e r_0)]$$

$$=\frac{q}{\pi\alpha}(lg_e x-lg_e y).$$

For the line (surface) *CD* the distances x and y are equal, which means that $z=H$. The same applies also to $x=y=\infty$. Thus, Forchheimer's imaginary well supplies, indeed, a solution for the flow problem on the right-hand side of the diagram. The left-hand side is, of course, purely imaginary.

To find the level in the well *AB* :

$$H^2-h^2=\frac{q}{\pi\alpha}(lg_e 2a-lg_e r_0),$$

from which

$$h=\sqrt{H^2-\frac{q}{\pi\alpha}(lg_e 2a-lg\, r_0)}.$$

It may appear from this equation that at a certain distance a_0 from the river we will have $h=0$, which, evidently, does not occur in nature, since beyond $2a=R$ the formula lacks significance. One may therefore assume for practical design purposes that for distances exceeding $R/2$ the effect of the river on the well performance is negligible.

Consider now a set of wells as shown in

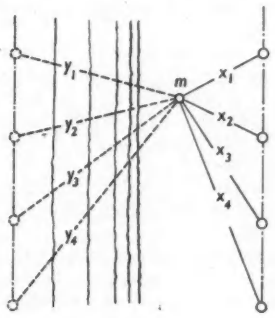


Fig. 15

Fig. 15, and suppose that the discharge of each well is q. Then

$$H^2-z^2=\frac{q}{\pi\alpha}(lg_e y_1, y_2\ldots-lg_e x_1, x_2\ldots)$$

Following the same principle it is easy to devise a solution for any type of well arrangement. For further information on the subject the reader is referred to Sichardt's book, which contains a large number of such solutions.

(*j*) Choice of System in Practice

The choice of the type of the well-point system in practice depends on various local circumstances. Instances extracted from irrigation practice in Egypt may serve as useful examples, explaining the nature of such circumstances.

On Nile barrages, the well-point system was first used in the remodelling of Esna barrage, and later, on the construction of Edfina barrage and other works. The conditions controlling the choice of the system at Esna barrage, however, were not the same as at Edfina, for the following reasons: at Esna the bottom of the excavation was at R.L. 68·00,[17] while the water level in the river, during the working period of the sudd, was at R.L.

[16] Loc. cit.

[17] The letters R.L., as used by irrigation engineers in Egypt, are an abbreviation for Reduced Level and refer to a conventional system of levels, measured above a datum which at a certain time was believed to be the mean sea level at Alexandria.

Fig. 16—Well-points, collector and pump of well-point system at Edfina barrage, 1949

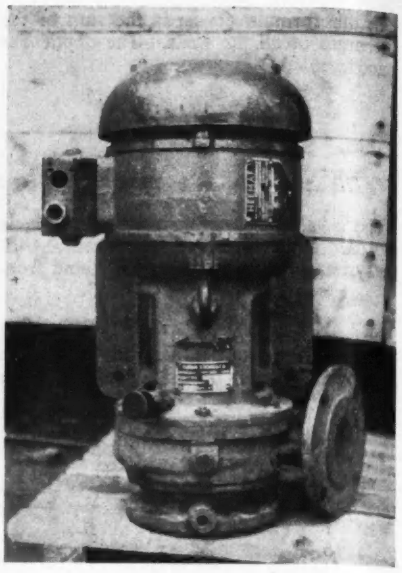


Fig. 17—Pump used on independent well-points in the Sudd of Edfina barrage, 1949

74·50 as a maximum ; that is, a head of about 6m. Whereas at Edfina the river level during the same period was at R.L. +7·50 and the excavation bottom at R.L. −8·00, corresponding to a head of about 9m.

This difference in heads was an important factor in the choice of the dewatering systems ; in fact, as already pointed out previously, there are two systems of well-point dewatering :—

(*a*) The collector system, in which the well-points work by suction (vacuum) and discharge above ground into a common pipe or collector, from which the water is evacuated by means of a pump of large air and water capacity.

(*b*) The system of wide wells, operated by independent pumps located below water level in each well.

The Moretrench system which was adopted at Esna barrage belonged to the first type.* Although 5m drops of ground-water levels ("draw-downs") produced by a single-stage installation of this type, are not uncommon in other countries—3m is believed to be a maximum for the Nile channel. This maximum is determined by reasons pertaining to the depth of the pipes and to the maximum practically feasible vacuum (that is, pressure less than that of the atmosphere).

It is essential to realise that the calculation of the saturation line forms an essential part of the project of such an installation, for in order to ensure efficient operation the flow of air into each well-point must be reduced to a minimum and the screens of the well-points must therefore be located below the saturation line.

On the other hand, with the system (*b*) using independent pumps located in each well below water level, we have always a positive pressure and the head may therefore attain any reasonable value ; but then the diameter of the well itself must be large enough to accommodate the pump and it takes some time to sink these wide pipes.

It follows that with the first system, the narrow pipes which may be sunk very rapidly may be put in place after the enclosure is unwatered by open pumping, whereas with the (*b*) type it is preferable to begin sinking the wide pipes some time earlier, even before starting to build the sudd, in order to have them ready in time.

* The Moretrench system is particularly described here because of its use on Egyptian barrages, but there are other firms also who specialise in similar dewatering works.

The installation at Esna barrage was of the two-stage type comprising, essentially, two lines of collectors with about 3m suction-lift each. Had the same system been used at Edfina as at Esna, it would have been necessary to provide three lines of collectors (three-stage type) to cope with the much greater head, and this would have been too complicated ; the system (*b*) was, therefore, adopted at Edfina as the main system, whilst open pumping and the (*a*) system were then used as auxiliaries.

The main characteristics of these two systems of well-points, as used at Edfina, are given below :—

(*A*) *Collector System.*—This was of the "Moretrench" type, the installation being generally the same as had been used earlier on the Esna barrage remodelling. These well-points are 2in diameter pipes, self-jetting and each 6m deep, connected above ground to 8in collectors (see Fig. 2 *ante*). The valves on the collectors (also described as "header lines") are spaced 0·8m apart, which means that, depending on local circumstances, the well-points may be spaced at distances of 0·8m, 1·6m, 2·4m, and so on. Every collector is operated by a Moretrench pump of 65 h.p. capacity delivering 65 litres per second (see Fig. 16). One pump usually controls about ninety well-points. It takes about five minutes to sink one well-point.

(*B*) *Independent Wells.*—These wells were 10in in diameter and were provided each with a "Sumo" pump of 7·5 h.p. capacity, delivering 18 litres per second. Both pump and motor were submersible, their combined weight being about 150 kg and cost about £300 (in 1948).

The diameter of the delivery pipe was 3in, but to reduce friction this was connected to a 6in pipe. The sinking of such a well took two days. First, a 20in pipe was sunk to about the level R.L. −20·00, that is about 13m below the deepest channel level. Then a 10in pipe (perforated and provided with a mesh screen in the lower 13m) was inserted and the outer, 20in pipe, was then gradually withdrawn, whilst at the same time gravel was poured in the space between the two pipes.

In addition to this, a lighter independent well has also been used, provided with a 3 h.p. "Stork" pump (see Fig. 17), discharging about 7 litres per second. Since the pump was in this case placed on the top of the well, it was of the suction type, the maximum vacuum being in this case 8m.

The spacing of the individual well-points, in accordance with the theory previously expanded, is a function of two factors : (*A*) The difference in levels between the natural and the depressed ground water surfaces and (*B*) D'Arcy's coefficient of permeability. The (*A*) factor is usually supplied by the drawings, but the (*B*) factor must be determined in the field, for each case separately.

There are two methods for doing this. Either abstract a sample of the soil and test it in the laboratory, or make a pumping experiment in the field and thus determine the required coefficient *in situ*. Both methods were applied at Edfina barrage by the contractors (Société des Constructions de Batignoles and Neverland Harbour Works). The first test was made in the laboratory on

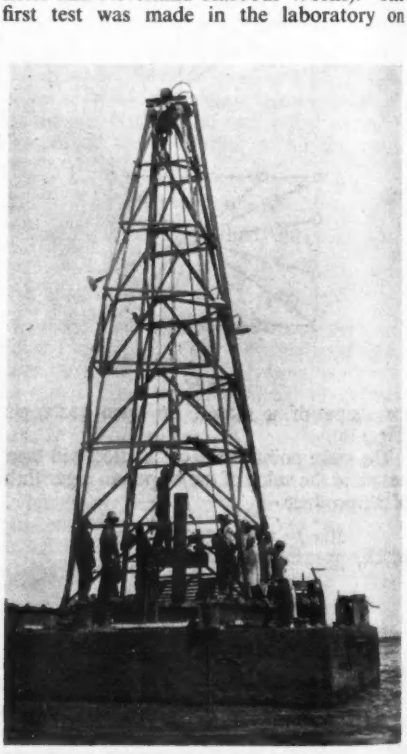
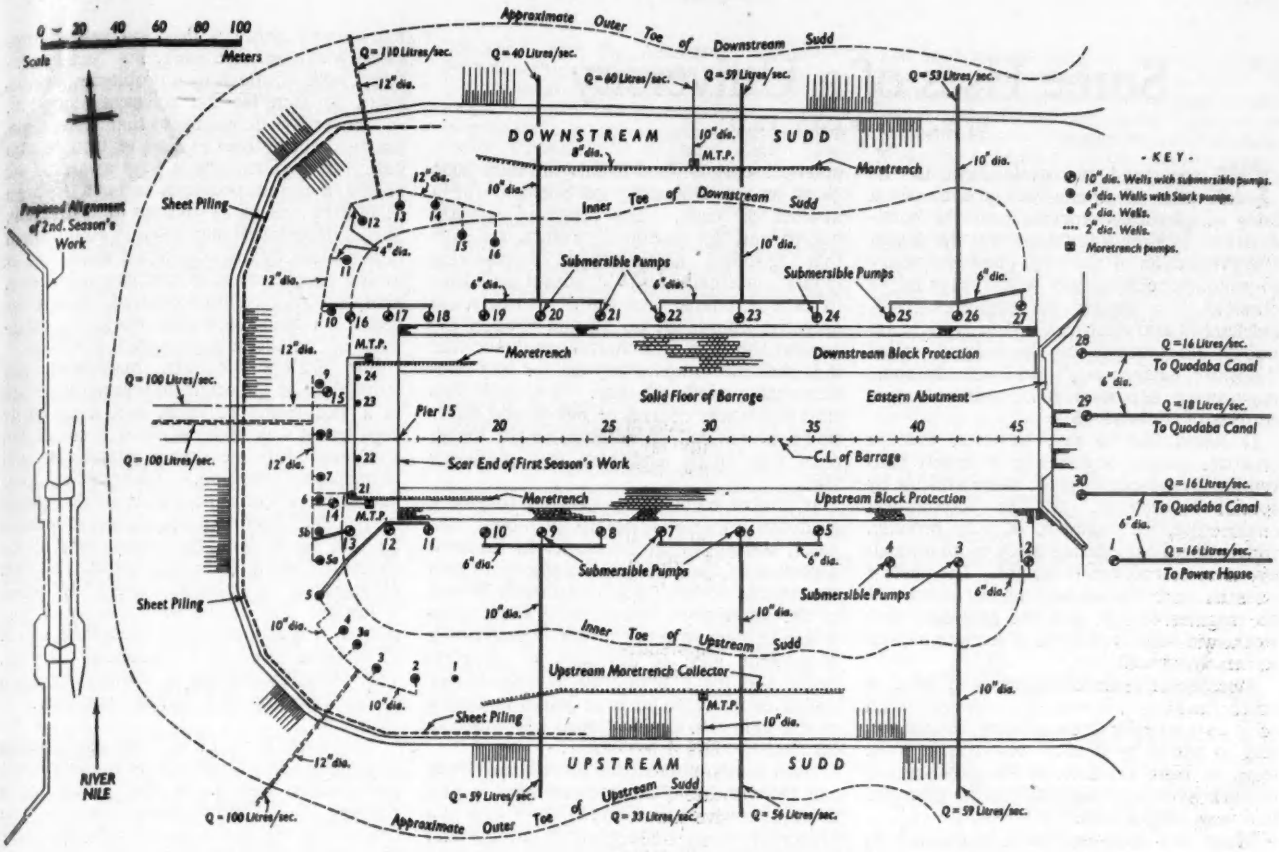


Fig. 18—Sinking independent well-points, before building the Sudd at Edfina barrage



Note.—Discharges shown as recorded on March 21, 1949. Nile level R.L. 1·58. Total discharge of pumps 76,500 m³/day.

Fig. 19—Example of dewatering layout, Edfina barrage, first season

samples 80cm by 20cm by 35cm, and gave values 240×10^{-6}m and 168×10^{-6}m per second for sand abstracted from levels R.L.−17·00 and R.L.−12·00, respectively. For the second experiment, two preliminary test borings were sunk, on the eastern bank of the river in the vicinity of the barrage.

A number of observation pipes were sunk at various distances from the central boring, in order to observe the depression of the ground-water surface caused by pumping water from the central well. This pump test gave values of the coefficient α varying from 300×10^{-6} to 500×10^{-6}m per second. The average value 400×10^{-6}m per second was then adopted for the calculation.

The sinking of the pipe-wells of large diameter on the site of the proposed enclosure was started before beginning to build the sudd. The work, therefore, was done from pontoons, as shown in Fig. 18.

This completes the description of a typical installation of a well-point system, as used in barrage construction works on alluvial rivers. We shall next describe how it works.

(*k*) Example of a Dewatering Scheme Operation

The first season of the construction of Edfina barrage can serve here as an example. The general layout of the dewatering system which was used during this season is shown in Fig. 19.

The closure of the first sudd took place on January 26, 1949, and thereafter the unwatering started by "open pumping" at a daily rate of drop of about 30cm.

Sixteen pumps were used, as follows :— 10 pumps 3in delivery, 4 pumps 10in delivery, 2 pumps 12in delivery.

The combined discharge of these pumps was 70,000 cubic metres per day.

When pumping started the water level in the river was at R.L.+0·15. By February 8th the water level in the sudd fell to R.L.−4·00. On this date the open pumping was discontinued and the well-point system began to operate. This consisted of the following :

(*a*) Thirty submersible pumps, 3in in diameter, in 10in wells.

(*b*) Fourteen "Stork" pumps, 3in in diameter, in 6in wells.

(*c*) Two Moretrench pumps, 10in delivery on 8in collectors, drawing water each from about ninety pipe-wells 2in in diameter (length of each collector about 180m.).

(*d*) Two Moretrench pumps of the same size as above but installed on a barge.

The total discharge of all these pumps was 60,000 cubic metres per day.

By the middle of February the sudd area was divided by a shallow dyke into two parts : the eastern part, close to the bank, with lesser percolation, which was dewatered down to the level R.L.−8·00, and the western part, nearest to the deep water channel, dewatered to R.L.−6·50 ; percolation was, of course, greater in this second part.

The same system was in operation in March, except that one Moretrench pump only was working on the pontoon. The combined discharge of these pumps was then 60,000 cubic metres per day, which sufficed to keep the water level in the sudd at R.L.−8·00.

Forty submersible and "Stork" pumps and three Moretrench pumps were in action in April. Of the three Moretrench pumps, two were installed on collectors and one on the pontoon. The combined discharge of these pumps was 50,000 cubic metres per day ; the pool level inside the sudd was still at R.L.−8·00.

The pontoon, on which the Moretrench pump had been installed in April, was removed from the enclosure in May and a new "V"-shaped collector was provided round the western scar end of the newly-built floor. The old northern collector (that on the downstream side of the sudd) was stopped and its Moretrench pump, as well as that which was removed from the pontoon, were both installed on the new collector. The length of this collector was as follows :

(*a*) Northern branch, about 60m.

(*b*) Middle part, 70m.

(*c*) Southern branch, 70m.

The spacing of the 2in pipe-wells, discharging into this collector, was :

(*a*) Northern branch, 1·6m.

(*b*) Middle part, 0·8m.

(*c*) Southern branch, 0·8m.

The new collector was, thus, fed by about 200 pipe-wells.

The total discharge of the pumps in May was 60,000 cubic metres per day. In addition to the forty-three well-point pumps, which had been used during this month, three 6in open pumps were added in June because percolation through the sudd increased and there was also a certain amount of water coming from the washing of the gravel on the sudd. These additional pumps were working periodically only, when required. Excluding these three open pumps, the discharge of the well-point system in June was 50,000 cubic metres per day (as before).

In July the removal of the 10in wells began and they were replaced by open pumping. The discharge of the pumps was estimated to be about the same as before. The water level in the sudd was kept at R.L.−6·00, viz., just below the level of the bedding under the block protection.

The water level in the river remained at about R.L.+1·50 up to August 11th. It rose to R.L.+2·22 on August 12th, when at the approach of the flood the annual sudd was cut, after completing the season's work.

Some Uses of a University

By R. P. N. JONES, Ph.D.

THE spearhead of development in the utilisation of atomic energy is clearly a body of physicists working near the boundaries of existing knowledge, but the design and production of the large plants necessary for practical realisation of what is in principle possible is a matter for engineers, civil, mechanical and electrical. Already there are books and journals on the subject called "nuclear engineering," and already some engineering departments of university give courses of lectures on it.

It seems fair to say, however, that in practice, nuclear engineering is largely conventional engineering made more difficult by special restrictions, just as aeronautical engineering, for example, is, very broadly, conventional engineering made more difficult by severe restrictions in weight. The nuclear scientist and the aerodynamicist need not be engineers at all, and the engineers they work with need know little of nuclear physics or aerodynamics.

Mechanical engineering needs at least as much learning as it ever did; every branch of it is naturally accumulating experience, and to profit by it each new recruit must learn at least as much as his predecessors unless he is content, very early on, to specialise in a very narrow field.

Much new published work in mechanical science tends to be academic rather than obviously practical and needs careful examination to identify any addition it may make to utilitarian knowledge of the subject. Much mathematical analysis has been carried out in connection with mechanical vibrations, for example, and to keep abreast of it is specialists' work. Nevertheless, a real grasp of simple basic principles is in itself often a great help in dealing with practical problems associated with vibration.

It was recognition of the advantage to be gained from learning more of such a subject as vibration than is possible in an undergraduate's course of study that suggested the establishment of means of giving directly useful post-graduate instruction to men who, through experience in industry, could appreciate its value. Courses of lectures and practical work devised to this end have been given in the University of Sheffield for a number of years. The range of subjects offered and the treatment of them are such that technical executives in engineering industry normally say, "I wish I had time to take a course like that." Clearly, an executive could not do so and such is the general shortage of technical assistance that it is difficult to spare anyone for any considerable period of time. To meet this situation, short courses of five weeks' duration are provided, in addition to the longer ones that many engineers can profitably take.

It is now common in industry to give a graduate an apprenticeship of about two years, during which he works in different departments, and it is desirable for such apprentices not to lose habits of study formed in the university. Inclusion of short post-graduate courses in such apprenticeship is a convenient way of avoiding a complete break and for a man who is destined for design or research, what he learns in such a course can give him a special advantage in his post-apprenticeship career.

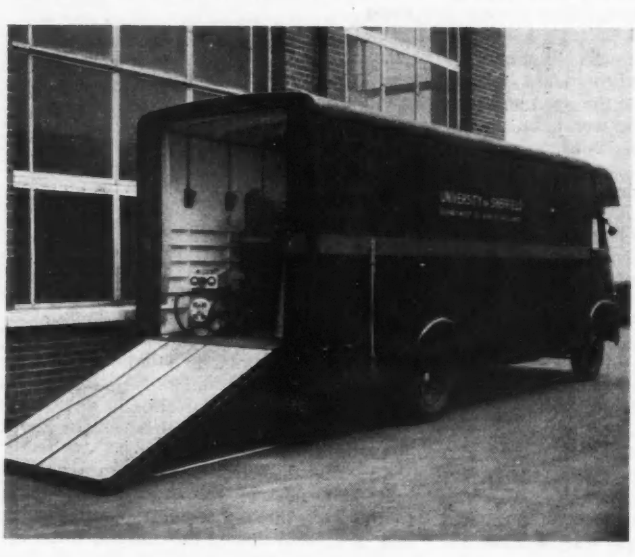
Such a man appreciates more clearly than can the average undergraduate what a gulf there is between acquisition of knowledge at a university in an undergraduate course and the application of that knowledge in industry. He realises that a degree course must have a fairly broad field and so can deal only with principles; there is insufficient time to spend much on practical detail. In a post-graduate course in a narrower field the position is different and instruction can be given in a form that can be recognised as valuable by the student who has some first-hand experience of the necessity in industry for compromises between academic ideals in analysis and practical possibilities in synthesis.

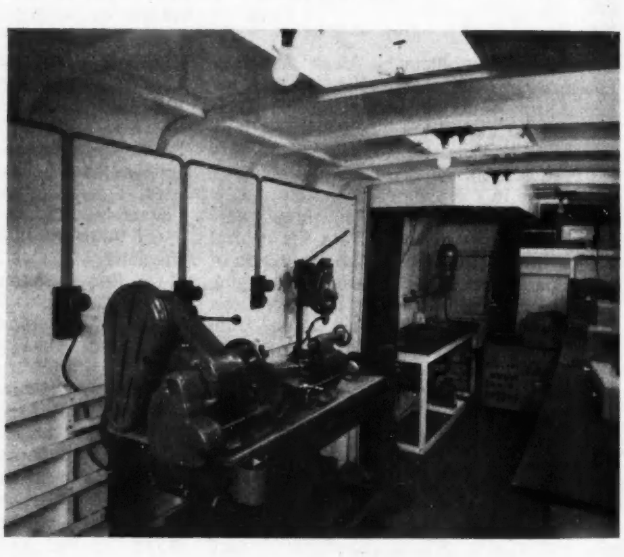
A university department associated with any technological subject is frequently approached for advice or suggestions for means of coping with some kinds of difficulty encountered in industry, not because a university can reasonably be expected to know more about a practical subject than those who specialise in it, but because different ways of attacking a problem can sometimes be seen from a different viewpoint. A university department that can make practical suggestions in time of trouble with design or performance is kept aware of the nature of current problems and can use them as illustrations in its courses of instruction. Such a department may also aid an industrial organisation by loan of special measuring or testing equipment in an emergency, but may, alternatively, earn more gratitude by showing that a few items of normal workshop equipment can be adapted to do what is wanted.

For example, certain machinery was thought to be the origin of marked vibration in a steel-frame building, and a university department was asked whether it could lend apparatus for measuring amplitude and frequency of vibration. This happened to be impossible at the time, but it was suggested that a pencil fixed to a heavy mass suspended by thin wires from the upper part of the structure would trace on a piece of card mounted on the frame at a lower level either a straight line or ellipse if the card were still, or a sine-wave if the card were moved at uniform speed in a horizontal direction. This procedure sufficed to identify the origin of the vibration and means were found to reduce it.

The work table of a large gear-hobbing machine made with great care in every detail, nevertheless seemed to the touch to be rotating in a non-uniform manner when driven by the motor in the normal way. An elementary vibration meter composed of two steel bars, two steel rollers and a standard "dial indicator" showed that this impression was well-founded as it indicated departures from uniform motion of the order of 0·001in several times per second with the table rotating at very low speed. Correction in this case was not an easy matter, but the elementary vibrometer gave a measure of improvements that were effected in a way that could not be bettered by any assemblage of instrumentation without hundredfold multiplication of time and labour.

Simple procedure of this sort in conjunction with practice in using modern electronic equipment to produce photographic records of vibration strongly reinforces book learning on the fundamentals of vibration.





Figs. 1 and 2—Mobile laboratory of the Department of Applied Mechanics, Sheffield University. It is equipped to take measurements of stress, strain and vibration in machines and structures either in factories or in the open

In the Postgraduate Department of Applied Mechanics at Sheffield University, work of this character is done by short-course students working alongside those who, during a longer period of attendance, also carry out research work generally by use of apparatus or machines designed and built entirely in the department. The student group is in fact composed of engineers of diverse experience.

It is not an object of this particular department to do fundamental research, and the main reason for including any research in its activities is that in industry design is closely linked with development, while development and research have no readily perceptible dividing line. The research items are necessarily of short-term character and most of them are concerned with specific problems that have arisen in the work of the organisation that is sponsoring the student. This enables staff and students to know something of matters of interest in various sections of mechanical engineering industry and it enables a student who attends for at least one session to do directly useful work for his employers whilst advancing his own education.

A recent addition to the department is the mobile laboratory illustrated opposite. It has a floor dimenions of 20ft by 7ft and is to take measurements of stress, strain and vibration in machines and structures working in factories or in the open. The equipment includes a high-speed camera (up to 3000 frames per second) and facilities for developing photographs from it, from cathode-ray tubes and from other instruments. The vehicle also houses electronic apparatus fed from the mains or by a 1kW portable petrol-engine-a.c. generator set.

The services of this laboratory are offered to industry for the purpose of assisting in investigations in places where the necessary instrumentation cannot otherwise be applied. Its use broadens the experience of the staff of the department and of those students who assist them whilst quantitatively investigating the characteristics of a machine or structure. It also emphasises the fact that the aim of the department is to give instruction and experience in the application of up-to-date techniques, on paper and in metal, to engineering problems that arise in industry.

British "Mouse" Satellite

IT has been announced by the British Interplanetary Society that a three-stage satellite rocket was the subject of a British design study in 1951. This study, made at the request of the Technical Committee of the British Interplanetary Society in August, 1950, was aimed at determining the smallest type of rocket vehicle that could be established in a circular orbit round the earth for scientific purposes. The project was later given the nickname "Mouse" (contrived from the initial letters of the words Minimum Orbital Unmanned Satellite, Earth) in association with proposals for a large instrumented satellite put forward by Professor S. F. Singer which were laid before the Society in 1954. It has been acknowledged in America that the British design studies supplied background information for the "Vanguard" satellite vehicle now under construction. The American satellite rocket, also three-stage, is scheduled to be launched from the U.S. Long Range Proving Ground, Cape Caneveral, Florida, during the International Geophysical Year (actually the eighteen-month period between July, 1957, and December, 1958). The "Mouse" design study was outlined in a paper, "Minimum Satellite Vehicles," at the second International Congress on Astronautics, in London, in September, 1951.

Points of similarity between the British "Mouse" and the American "Vanguard" projects are summarised below :

Three-stage construction ; use of pivoting rocket motors for stability and control ; omission of guide fins ; propellant tanks integral with the rocket structure, to produce useful weight economics (i.e. improved structural ratio) ; all guidance equipment relegated to second stage ; steam-jet controls (hydrogen peroxide gas generator) employed in second stage for moving rocket into desired orbital plane after cut-off of driving motor ; use of spherical body, ejected from third stage, as artificial satellite.

Inflatable Satellite.—A novel feature of the "Mouse" project was the suggestion that an inflatable satellite might be carried in the third step and ejected from the rocket after it had arrived in the orbit. In view of the near-vacuum conditions prevailing at the altitude of release, it was considered that the satellite could take the form of a light metal-foil sphere which would be blown up by means of a capsule of gas to a large diameter—perhaps 6ft to 8ft. A body of this size would be clearly visible by the sun's reflected light just before dawn and shortly after sunset. It compares with the rigid instrumented satellite of only 20in diameter of the "Vanguard."

It was recently reported in America that two kinds of artificial satellite may be developed in the "Vanguard" programme—one that would emphasise the gathering of telemetry data (a radio method) and another which would take the form of a large inflatable sphere with excellent visibility, but containing no instruments. The latter would be tracked optically from the ground. One of the most important uses of such a satellite would be to determine air drag in the outer atmosphere, by measuring the rate at which the body loses height and speed along its orbital track. This will have importance in the design of new high-altitude rockets and rocket aircraft. Another use for the satellite would be to obtain precise measurements of the shape and dimensions of the earth, which at present are far from accurately known. For example, there is still uncertainty about the relative positions of the continents, amounting to hundreds of feet in the case of America and Europe. This can be achieved by triangulation from ground stations using the satellite as a point of reference. The Americans are also claiming that it may be possible, using their instrumented satellite in conjunction with a radio tracking method, "Minitrack," to determine the distribution of the earth's crustal mass ; small variations in the local value of gravity are expected to cause slight but measurable distortions of the orbital path.

Technical data for the two satellite projects are outlined below :

	British "Mouse" (design study only)	American "Vanguard"
Date of origin ...	1951...	1955
Height of orbit ...	500 miles (max.)	200 to 800 miles
Launching vehicle	3-stage	3-stage
Length (overall)...	51ft	72ft
Diameter (max.)	74in	45in
Weight (take-off)	37,000 lb... ...	22,000 lb (min.)
Propellant	Nitric acid/hydrazine (all stages)	Liquid oxygen/alcohol-gasolene (stage 1) Nitric acid/dimethyl-hydrazine (stage 2) Solid, long-burning (stage 3)
Payload	Inflatable sphere of metal foil, 6ft to 8ft diameter	Rigid instrumented sphere 20in diameter (weight 20·5 lb)

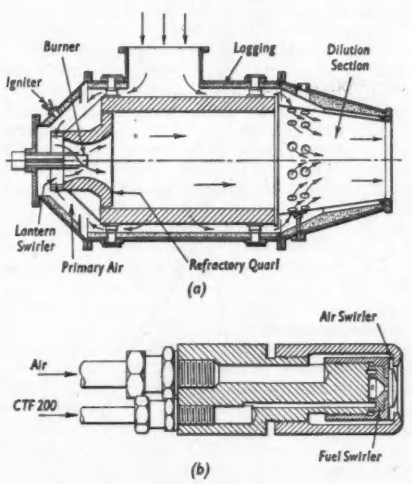
Coal Tar as Fuel for Gas Turbine

OUR full description of the Ruston "TA" gas turbine, published on March 13, 1953, recorded that one engine was to be installed at the works of the Crittall Manufacturing Co., Ltd., to drive an 11kV alternator and fire a high-pressure boiler. This machine has now been commissioned, and we recently visited the factory at Witham, Essex, to see it in action.

The factory, which produces over 450 tons of steel windows each week, requires electricity largely for welding machines, involving peak currents on two phases at a time, and process heat often at high temperatures for paint-drying ovens. The alternator used is a 1500 r.p.m. B.T.H. salient-pole revolving field machine, and has a normal rating of 1000kW, equivalent to the overload output of the gas turbine. The welding load demands rapid voltage control, and a "Magnestat" automatic regulator has proved satisfactory, whether the turbo-alternator is running in parallel with the mains or alone.

The high-pressure boiler is a La Mont unit built to run at 200 lb per square inch. Changes in the works load since the original design study have caused a pressure of 125 lb per square inch to be employed, with a resulting increase in the heat recovery from the turbine exhaust. To provide heat beyond that available from this source, the boiler can be fired by three Wallsend low air pressure burners, and to provide a depression around them an induced draught fan is driven at 485 r.p.m. by a 40 h.p. English Electric induction motor. A by-pass is provided to allow the turbine to exhaust direct into the stack, and a set of dampers regulated by Electroflo equipment governs the gas flow.

The space heating system of the factory runs at full boiler pressure, but a number of other services are supplied from this system. Calorifiers raise steam at 15 lb per square inch to heat the pickling tanks of the galvanising plant.



Coal tar fuel for gas turbine : (a) refractory-lined chamber, (b) air-assisted burner

Another calorifier, supplemented by two 32kW electric heaters, provides hot water to heat the fuel, which for both turbine and boiler is creosote pitch of 200 sec viscosity. Completely separate pumping, heating, and straining installations are provided for boiler and turbine, both drawing from a pair of 11,000 gallon cylindrical tanks which have two 12kW immersion heaters each as well as hot water coils.

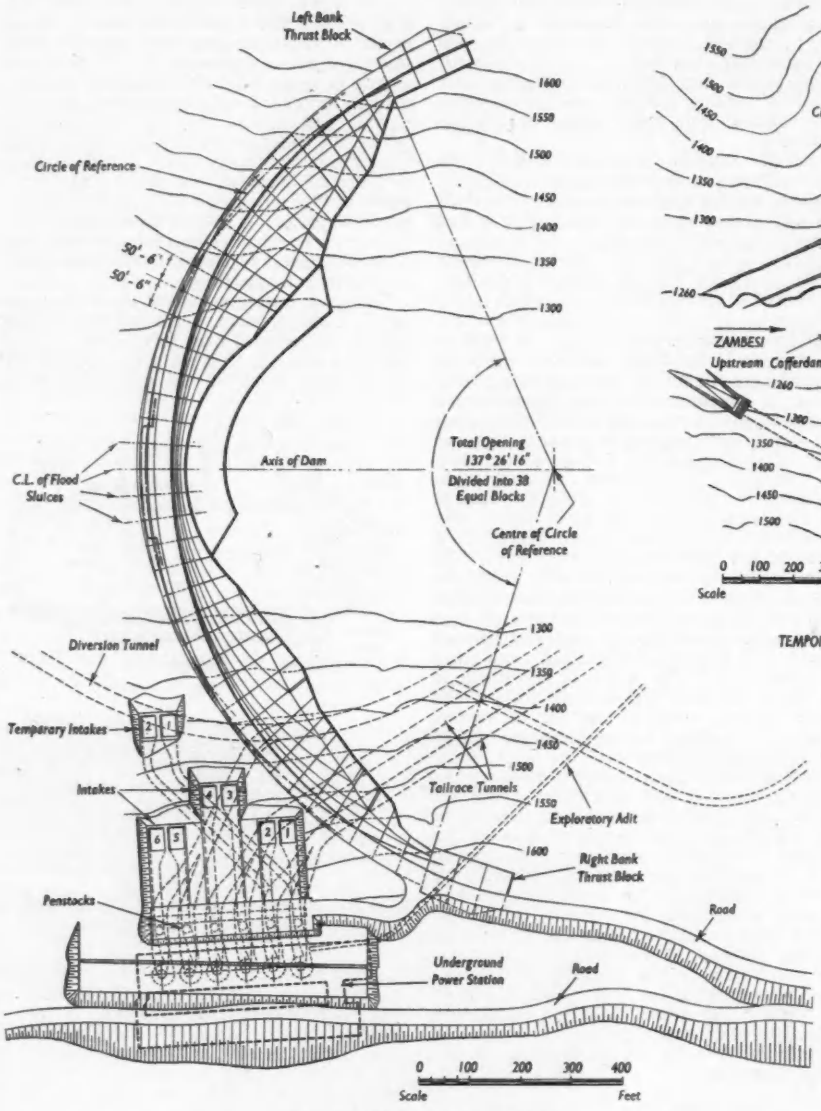
The turbine fuel system can supply 137 gallons of coal tar at 200 deg. Cent. every hour. The combustion chamber is lit up with "Calor" gas stored in a 32 lb bottle, and the engine is motored by a 24V lead-acid battery. In order that the set can be completely independent of mains electricity, provision is made to supply it with the gas oil used by the two Ruston diesels in the power house ; this involves replacing the air-assisted burner by a pressure-jet pattern, but does not cause great delay.

The coal tar burner and the refractory-lined combustion chamber are illustrated in the accompanying figure. The air for the burner is bled from the outlet of the main compressor, passed through an intercooler, and doubled in pressure by one of two twin-cylinder Broom and Wade compressors governed by automatic pressure ratio control equipment.

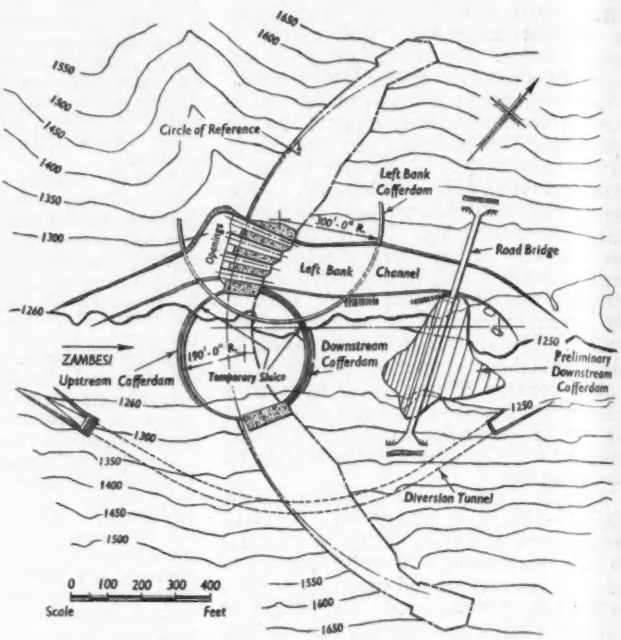
The fuel is specially prepared with a controlled sodium content, and is advantageous in being free from vanadium.

The overall thermal efficiency of power generation and heat utilisation of this gas turbine plant is 60 per cent ; it is interesting to note that the easy starting and quick acceptance of load allow the turbine to be shut down during the lunch hour. This factory is the first in Great Britain, other than those of engine manufacturers, to employ a gas turbine, and this plant is claimed to be first in service burning coal tar fuel.

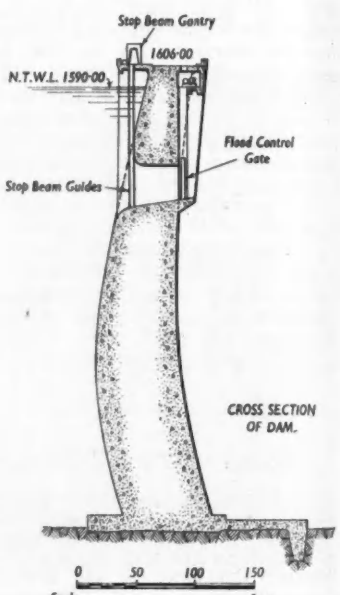
KARIBA DAM AND UNDERGROUND POWER STATION

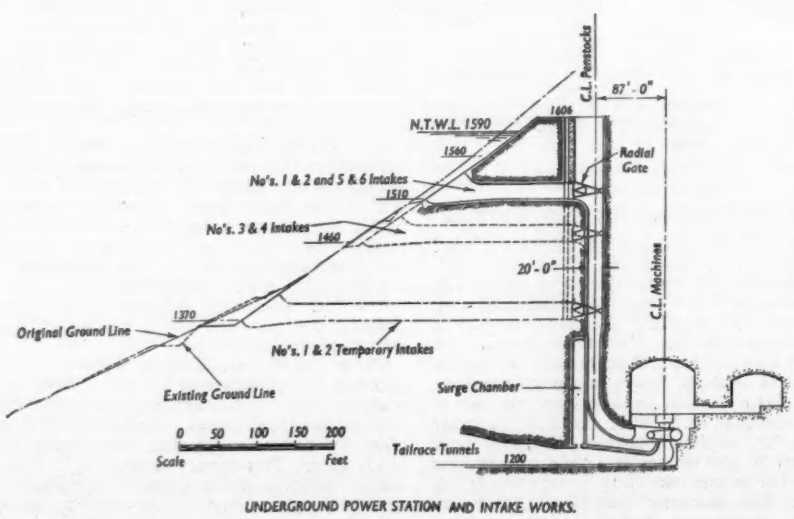


PLAN OF KARIBA DAM AND POWER STATION.

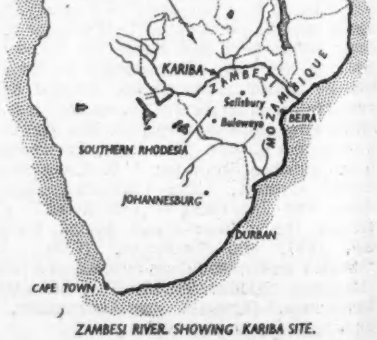


TEMPORARY RIVER WORKS FOR CONSTRUCTION OF DAM.





UNDERGROUND POWER STATION AND INTAKE WORKS.



ZAMBESI RIVER, SHOWING KARIBA SITE.

Kariba Hydro-Electric Scheme on the Zambesi River

The main contracts were recently placed for the construction of the first stage of the Kariba hydro-electric scheme, which is to be built on the Zambesi River in the Federation of Rhodesia and Nyasaland. We give here a description of the main elements of the scheme, listing the most important statistics relating to it; the principal firms concerned with its design and construction are also named.

IT was at one time considered that the world's greatest resources of hydro-electric power were to be found in Africa. Recent studies, however, dispute that view, and it may be that in Asia there are even greater potentialities. Both areas stimulate the engineer's imagination, the more so because at least some degree of practical achievement is in sight. An indication of some recent work on Asian sites was given in our review of section "H" of the fifth World Power Conference, held last June. In Africa, constructional achievement up to the present has been limited to schemes which are small when compared with the scale of the major sites. French North Africa can show some worthwhile achievements, and a power house is at present under construction at the existing Aswan dam in Egypt. But further south, only a modest, though, nevertheless, commendable, start has been made at Owen Falls. Kariba Gorge, on the Zambesi River, is therefore the first of the really large sites to be developed. So the recent announcement of the award of the main contracts for the first stage of the work there has aroused no little interest.

In a leading article in last week's issue of THE ENGINEER we commented on some of the background to the promotion of the scheme. Here we are concerned only with a description of it. A good general idea of the scheme is given by the drawings opposite, and by the accompanying table, which lists the principal data governing its design. The layout of the scheme is very simple. The gorge is plugged by an arch dam about 400ft in height, which serves the dual purpose of forming the reservoir, and creating the head for the turbines. An underground power station is to be built beneath the right bank of the gorge, with tail-race tunnels leading back into the Zambesi River just below the dam. The second stage of the scheme envisages a similar underground power station under the left bank. The machine hall of the power station will be 460ft long and the main transformers will be installed underground.

Kariba Hydro-Electric Scheme

Capacity of scheme :	
Ultimate installed capacity	1200MW
Firm annual energy output	8145×10^6kWh
Dam :	
Maximum height of dam	405ft
Length at crest (developed along circle of reference)	1919ft
Volume of concrete in dam	About 1,400,000 cubic yards
Reservoir :	
Flood water level...	1605ft (a.s.l.)
Normal maximum retention level ...	1590ft
Area of reservoir at normal maximum retention level	1,300,000 acres
Total capacity at flood water level ...	150×10^6 acre-feet
Active operational storage...	37×10^6 acre-feet
Flood storage	19×10^6 acre-feet
Corresponding operating range of levels :	
For power storage	30ft
For flood storage	15ft
Flood gates in dam	4 gates each 31ft by 30ft high
Maximum flood discharge through gates	About 260,000 cusecs
Mean annual river flow	$34 \cdot 9 \times 10^6$ acre-feet
Power station :	
Initial installation of sets in right bank power station...	5×100MW
Ultimate installation of sets in right bank power station...	6×100MW
Net power station head	About 300ft
Equivalent diameter of tail-race tunnels	36ft
Ultimate installed capacity with left and right bank stations	1200MW

There will eventually be six turbo-alternator sets in the power station, each of 100MW capacity and with Francis turbines. The intakes for these machines are grouped in pairs, as the drawings show. The first two sets will be built with temporary intakes at an invert level of 1370ft, so that they can be brought into operation sooner, at a reduced net head of about 150ft, before the reservoir has filled. Power is expected from these two sets early in 1960. However, as the reservoir rises to its ultimate top water level, the temporary intakes will become submerged too deeply for routine maintenance tasks to be carried out satisfactorily. Permanent intakes will, therefore, be built at a higher level. The phasing of this stage of the work can be gauged from the figures in the table—130 million acre-feet of water must be collected to fill the reservoir, and the annual flow is about 35,000,000 acre-feet. The tail-race tunnels from the turbines lead off towards the river below the intake tunnels; one pair of machines will make use of the downstream part of the diversion tunnel. The upstream part of this tunnel will be plugged as soon as construction of the dam is sufficiently far advanced.

A point of interest is that the only provision for discharging water when the turbines are not in operation consists of the four sluice gates. These gates, however, have a capacity greater, by a certain factor of safety, than the largest recorded flood, and there is appreciable storage capacity above the operating level of the gates, as can be seen from the cross-sectional drawing of the dam.

River Works for Constructing the Dam

The upper right-hand diagram on page 154 shows the sequence of temporary works needed to control the Zambesi at the dam site during the early stages of construction. There are three main stages in this sequence.

First of all, a diversion tunnel, with an equivalent diameter of 37ft 6in, is necessary on the right bank side. The tunnel will take only part of the river flow, but enables construction of the left bank cofferdam to proceed, to enclose and dewater a substantial area on the left bank of the site. The cofferdam is a concrete structure in the form of a thin circular arch. These two works—the diversion tunnel and the left bank cofferdam—were let as preliminary contracts and work on them has been under way for some time. It is planned that they should be finished this year, and a start should be made during the year on the construction of the isolated block of concrete shown on the right bank side. Work can proceed here when the river is reasonably low. At the same time the blocks shown inside the left bank cofferdam will be built. Gaps will be left between them to take part of the river flow in the next stage of work.

The first stage also involves cutting the left bank channel, above and below the left bank cofferdam. This, too, is scheduled for this year and is part of the preliminary contracts. When work is complete inside the left bank cofferdam, gaps will be blown in it, opening the diversion channel for part of the river flow. Then construction of the downstream preliminary cofferdam will be started. This stage of work is scheduled to be reached in the middle of next year. The cofferdam is a rock-fill structure, which will be gradually formed by tipping into the swiftly-flowing stream of the river, and its main function will be to cut the flow in the main channel, thus giving still water in which it will be possible to build the central steel-sheet-piled cofferdam shown in the diagram. The deepest part of the Kariba dam will be constructed in the cover of this cofferdam. Work will also proceed on the shore side of the large isolated block of permanent work forming part of this cofferdam. Thus the problem of controlling the river flow will be tackled, and in the last stage the gaps at the left bank side will be plugged, and the upstream portal of the tunnel plugged, when construction is sufficiently far advanced for the crest of the new work to be kept a given height above the rising level of the impounded water.

The Main Contracts

The Kariba scheme is being administered by the Federal Power Board, a body formed specifically for the purpose, in the first place, though doubtless it will be responsible for building and operating other hydro-electric schemes in the Federation later on. The civil engineering consultants for the scheme are Gibb, Coyne, Sogei (Kariba) (Pvt.), Ltd., a firm created locally by the parent consulting engineers, namely, Sir Alexander Gibb and Partners and the two French consulting organisations, A. Coyne and J. Bellier, and Société Générale des Exploitations Industrielles. The consulting engineers for the electrical and mechanical work are Messrs. Merz and McLellan.

The Federal Power Board states that tenders for the main civil engineering contract were received from five separate groups of contractors. Three groups made offers which were keenly competitive for a contract of such magnitude. Between the time of issuing invitations and the closing date for tenders, modifications in specification, mainly in the design of the dam structure, were made, and the three competitive groups were invited to reprice their tenders accordingly. The Board decided to accept the tender of Impresit (South Africa) (Proprietary), Ltd. A company to be called Impresit (Kariba) (Pvt.), Ltd., will be created immediately it is stated, and the following firms will be members of the company :—Impresit South Africa (Pty.), Ltd., Impresa Ing. Lodigiani S.p.A., Imprese Italiane Allestero S.p.A., Impresa Umberto Girola, Dott Ing. Giuseppe Torno and C.S.p.A., Impresit (Rhodesia) (Pvt.), Ltd. A formal contract will be made with Impresit (Kariba) (Pvt.), Ltd., and the Board will receive guarantees from each of the member companies mentioned. The revised tender price of Impresit South Africa (Pty.), Ltd., for a top water level of 1590ft was £25,278,000.

This price was £1,466,000 less than the next lowest tender and £2,271,000 less than the third lowest. The contract includes: construction of additional temporary site works; cofferdams and other temporary structures; construction of the concrete arch dam and spillway works; construction of the right bank underground power station and associated works; various surface buildings; certain permanent access roads; cofferdams which will later be required for the future left bank intakes. Much of the preliminary work at the site, such as the river diversion tunnel and cofferdam foundations, has been carried out by the Cementation Company, Ltd. A temporary power plant of some 6000kW capacity and certain other constructional plant will be obtained from Britain.

Details of the electrical and mechanical awards are as follows: five 140,000 b.h.p. water turbines, Boving and Co., Ltd., London, £1,072,583; five 100MW water-turbine-driven generators, Metropolitan-Vickers Electrical Export Company, Ltd., Manchester, £1,772,065; 330kV transformers: ten single-phase, 15/18/330kV generator transformers for Kariba, English Electric Company, Stafford, £622,500; substation transformers, Ferranti Ltd., Hollinwood, £1,333,200, involving transformers at Kitwe, Norton, Salisbury, Umniati and Bulawayo; there will be thirteen substation transformers, three-phase units with maximum rating of 120MVA, for Kitwe, and 60MVA for the remaining transformers. The rated higher voltage is uniformly 330kV, but the rated lower voltage between phases is 220kV for Kitwe, 33kV for Salisbury and Bulawayo, and 88kV in other cases.

Overhead electric travelling cranes, Babcock and Wilcox, Ltd., London, £108,292 (two overhead electric travelling four-motor cranes for the underground power station, to lift 200 tons); shunt compensating reactors, C. A. Parsons and Co., Newcastle, £191,920; 330kV steel tower transmission lines, Rhodesian Power Lines (Pvt.), Ltd., Salisbury, £9,935,844. The transmission system will be: section "A," Kariba power station to Kitwe (275 miles); section

"B," Salisbury to Norton to Sherwood (Umniati), to Bulawayo (260 miles); and section "C," Kariba power station to Norton and Kariba power station to Sherwood (Umniati) (170 and 220 miles). Line conductors will be twin 0·35 square inch steel-cored aluminium carried on steel towers. Rhodesian Power Lines (Pvt.), Ltd., will carry out the work as the accredited Rhodesian counterpart of Societa Anonima Elettrificazione, of Milan. In carrying out the contract, considerable quantities of British equipment will be used, notably toughened glass insulators and steel-cored aluminium conductors, estimated in value at approximately £4,000,000.

Decisions remain to be taken in the next few months on the following important contracts: main and auxiliary switchgear, 330kV and ancillary cables, 330kV switchgear and 11kV air-blast switchgear, transmission line survey south of Brokenhill and civil engineering works, including intake gates, screens, gantries, draught tube gates and tail-race outlet stop beams. The estimated cost of these contracts is £4,000,000.

Contracts already awarded by the Board include: preliminary works, Cementation Company, London, £1,593,780; housing and associated works, Richard Costain (S.R.), £3,523,175; camp electrical installation, Hubert Davies and Co., Johannesburg, £114,049; Matthew Hall and Co., Bulawayo, £123,138; access road south, irrigation division of Southern Rhodesia Government, £310,000, and John Laing and Co. (Rhodesia), £462,000; North access road, A. G. Burton, Ltd., £780,000; petrol and diesel oil, Shell Company of Rhodesia, £1,500,000 approximately; transport, Kariba Transport Company, £2,000,000 approximately; railway siding and ancillary works, John Laing and Son, £146,720. Various smaller contracts total £250,000.

Supercharger Development

The piston type supercharger designed by Sir Harry Ricardo has now been developed to demonstrate in practice the advantages predicted in theory. It has been applied to four-stroke engines, particularly for automotive purposes.

THE road vehicle burns an exceedingly expensive fuel, and even the diesel engine does not satisfy the ambition of operators for economy. Nor is it sufficient for the engine to attain low specific fuel consumptions: since the engine is part of its own burden, weight is begrudged to it. And great store is set by ease and cheapness of upkeep. A way of reducing engine weight that has merited much attention is to perform the initial stage of air compression, not with the necessarily strong pistons that work in the power cylinder, but in a relatively light low-pressure compressor. The same philosophy, of course, calls for the final stages of expansion to take place in a turbine, and results in the turbo-blower. The vehicle engine, unlike a propeller—or generator—driving plant, is normally required to develop the maximum possible torque at low speeds and, hence, low air consumptions, and for this reason the exhaust turbine is not attractive unless used in a vehicle with torque converter transmission. Moreover, the engines of British vehicles are generally so small as to make the construction of an efficient exhaust turbine expensive. The positive displacement blower promises to give a sustained charge pressure at low engine speeds, but if specific consumption is not to suffer, a high adiabatic efficiency is required. It was for this exacting application that Sir Harry Ricardo proposed the supercharger which we illustrated on September 16th last, page 396, and which has a constant built-in pressure ratio.

The design of Ricardo and Co. (1927), Ltd., drawings of which we reproduced, has been modified in many details during its development by Wellworthy, Ltd. It is a feature of the machine that the valves and pistons do not touch the surfaces of the casings within which they move, but have finite and very small clearances. Maintaining these clearances over a wide range of working temperatures has involved some unusual detail design. Originally, the main shaft carrying the valves ran in a ball bearing and a parallel roller bearing allowing axial movement; but since the outer races were an interference fit in light alloy castings, it was found that some radial play developed as the outer casing lightened its grasp on the race, and the valves consequently touched their housings. The present shaft runs in taper roller bearings, and they are preloaded with an axial nip of 0·004in; a supercharger which had performed three 100-hour runs at 4000 r.p.m. was seen to bear only slight visible traces of contact on the running faces of the valves. The valves themselves, cast in magnesium, are liable to distort, since they have passages for both intake and delivery air and never run at a uniform temperature; although Wellworthy, as piston manufacturers, would be prepared to cam grind the valves, it is not at present expected to prove necessary.

To render the unit readily adaptable to engines of various sizes, it is usually belt driven, and the service life of the bearing at the drive end of the shaft has been improved by using a larger assembly on a mounting sleeve. The shaft, which is now solid, carries at its centre the detachable inclined journal which constitutes it a Z-shaft, and hereon the wobble plate runs on a pair of angular contact ball bearings. Here, again, differential expansion between the outer races and their light-alloy housing gave trouble, it being found that relative movement took place under the cyclic thrust variation and the race beat away the adjoining light alloy face. A bronze ring, honed to a highly uniform thickness, is now included between the side of the race and the housing, and the only effect of service is that the maker's marks on the race are reproduced on the ring. The reduction in interference with heating gives a slight increase in outer race diameter, and so, although the inner races are separated by a light-alloy flange, it is necessary to assemble the wobble plate selectively — it is put together without force when the parts are hot from the degreasing plant—to give the bearings a slightly tight feel. It is found that the least imperfection in the ball bearings feels evident on this component.

During development trials, one engine ran away due to an oil seal on the main shaft allowing oil to join the charge air. The seals are now "Neoprene" instead of leather, and show no signs of deterioration in use. The shaft is safeguarded from fatigue by having the screw threads rolled and being toughened. An innovation on the shaft assembly is a pair of balance weights running in the delivery chests; these cancel the couple associated with the swash-plate action of the moving parts.

The shape of an early die-cast light alloy wobble plate can be seen in Fig. 1. Development has been directed towards reducing its radius of gyration, and it has proved possible to dispense with a surprisingly large mass of metal. The pins which drive the piston rods have been progressively shortened until now they do not enter the central boss of the plate, which is drilled only with small holes to feed oil to the pins. In the original compressor, the wobble plate was restrained against rotating with the shaft by one of the piston rods, which was pivoted to its cylindrical slider on the radial pin by two ball bearings. However, the narrow range of movement to which the bearings were subjected caused rapid deterioration, and this scheme involved having one rod, and its bushes, $\frac{3}{16}$in in diameter, while the other six were $\frac{1}{8}$in. The wobble plate is now restrained by a pivoted block of "Lo-Ex" alloy, running in a cast iron guide; this casting is at the bottom of the casing and carries the oil outlet, drillings being made to lead some of the oil to the wearing faces. An all-steel spider-style wobble plate, such as appeared in the drawings, may be used in the future.

The stainless steel piston rods now run, not in long guides, but in two bushes at each end. The inner bush is W.85 light alloy, and the outer of bronze lined with white metal. No positive oil supply is allowed to the outer bushes, the trace of oil applied by the inner bushes sufficing; hence, there are no packings on the rods.

The pistons are magnesium, with labyrinth grooves round their periphery. They currently run with a radial clearance of about 0·0011in, but experiments have been conducted with smaller clearances. Early machines had the pistons secured by castellated nuts and split pins, but to reduce the chance of small parts being dropped into the air spaces the design was changed, the pistons being mounted on screwed sleeves retained with all-steel self-locking nuts.

The blower is lubricated from the engine oil system, it being expected that heavy duty oil will be used. The oil is fed by a radial pipe into a gland on the shaft and passed by centrifugal force to the piston-rod sliders and bosses. Small drillings allow compressed air to bleed into the centre of the casing, so that scavenging does not rely entirely upon gravity.

The present production compressors, when completed, are run in for three-quarters of an hour and then checked for efficiency against a delivery pressure of 22in Hg. They are then tested by prolonged runs at 2000 and 3000 r.p.m. against pressures up to 18in Hg.

The characteristics of the blower are plotted in Fig. 2. It is clear that a good approach to a constant volume characteristic is obtained, although there is some throttling at high speeds. A striking feature is the wide spacing of the efficiency contours: in particular, the pressure ratio can be raised above the internal compression ratio with very little effect. When combined with one particular engine, the supercharger would ideally run at a constant boost settled by the swept volumes; since, however, the unit will rarely run on the low-speed side of maximum efficiency, the running line will tend to rise with increasing speed.

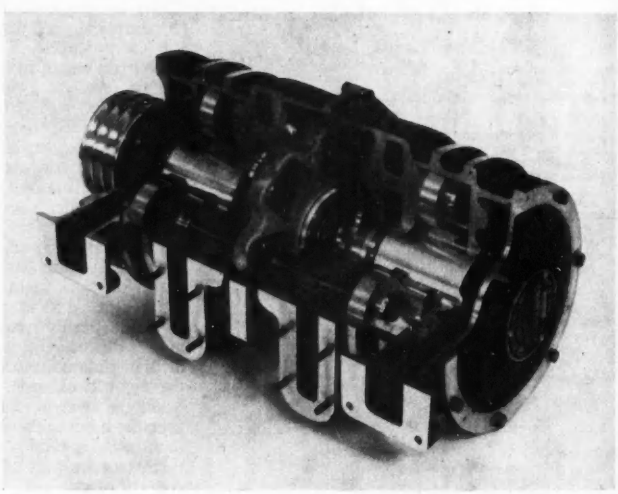


Fig. 1—A sectioned supercharger, showing the ports in the rotary valves

Engine trials have been carried out on two Leyland "Comet" trucks owned by Wellworthy, Ltd. These were the early model and have normal control, so that the blower can be accommodated under the bonnet on the near side of the engine. The fuel pump with 7½mm plungers was replaced by a unit with 8mm plungers and a mechanical governor. The injectors were not altered in any way. The blower was driven by a set of three steel-cored

vee belts at about 1·42× engine speed, and a corrected pressure ratio of 1·6 resulted. It was found that at 1500 r.p.m. the fuel feed could be increased to give 58 per cent more power than the unblown engine, a b.m.e.p. of 164·7 lb per square inch, with a clear exhaust ; since this meant that the 350 cubic inch engine was giving the torque of the normal Leyland 0.600, " it

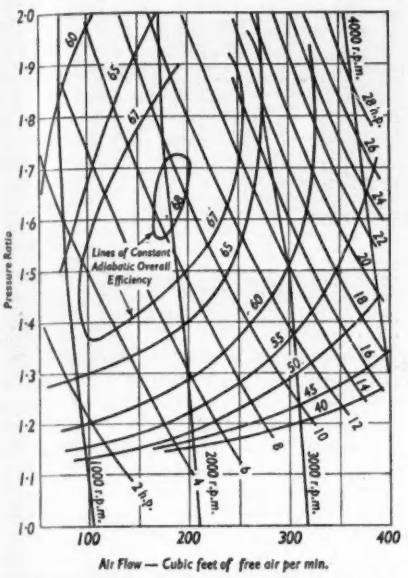


Fig. 2—Characteristics of Wellworthy-Ricardo supercharger

was thought imprudent to further increase the power." The pump was finally set to give about 40 per cent more torque than the unblown engine, and the timing retarded for injection to commence 19 deg. b.t.d.c. The full fuel performance of the engine with and without supercharger is shown in Fig. 3 ; it is, it will be seen, a " Comet " 90, and was boosted to 118 h.p. Noteworthy are the fuel consumption curves : since the thermal efficiency of this engine tends to fall with increasing speed, it is clear that, for the same power, the blown unit running at a lower speed can offer a markedly smaller fuel consumption. It appears also that secondary injection is setting in above 1800 r.p.m., so that further improvements are possible at high outputs. Testimony to the improved combustion in the blown engine comes from measurements at 1200 r.p.m., where, it can be seen, b.m.e.p. was 149 lb per square inch, against 106 lb per square inch ; the peak cylinder pressure was raised from 1100 lb per square inch to 1300 lb per square inch only, and the blow-by from 14·6 cubic feet per hour to 15·7 cubic feet per hour.

Consumption loops were also plotted at 1500 r.p.m.; at b.m.e.p.'s below 90 lb per square inch the normally aspirated engine is more efficient, but above 100 lb per square inch the supercharged engine shows to advantage, its minimum specific consumption occurring at a higher b.m.e.p. than the normal engine can attain.

The lubricating oil temperatures were substantially the same, whether the engine was blown or not.

When two " Comet " trucks, one blown and the other standard, each loaded to gross about 12 tons 10 cwt., were tested together, it became clear that the advantages apparent on the test bed could be realised in practice. Each truck had a two-speed axle to supplement the five-speed gearbox, so that any advantage in torque could be translated to higher road speed and overall efficiency. When the supercharged engine was running light a gentle hum, by no means discordant, could be heard from the compressor, while it was immediately noticed that the combustion noise had changed from a crackle to a deeper drone. On load, the blower became inaudible, and there was no increase in exhaust noise over the normal vehicle ; the engine seemed smooth and well within its powers. With the supercharged engine and closely spaced gear ratios there was no difficulty in accelerating from a standing start to high fifth gear on a slight adverse gradient, while timed runs on the level showed that the acceleration was consistently 50 per cent higher than that of the normal vehicle. A severe gradient, climbed from a rolling start, was also used to compare the vehicles' performance ; the blown wagon climbed in forty-four seconds, without dropping below low second. The standard vehicle, even in the hands of a driver completely familiar with it, could not do better than sixty-four seconds in high first. The difference in performance is most apparent to the driver, the supercharged engine feeling always a split shift better, and there can be little doubt that reduced gear changing is one of the causes of the improved fuel consumption. The ambient temperature when we observed the vehicles was high, and even the blown engine could be made to smoke at high torque and low speed. Prolonged high power outputs also caused it to boil, but the cooling system was the same as that of the " Comet " 90.

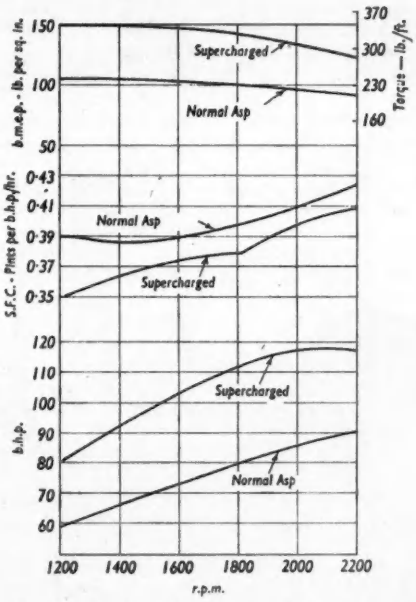


Fig. 3—350 cubic inch Leyland engine : maximum output

Besides these vehicles, the superchargers have also been supplied for experimental purposes to Leyland Motors and other engine manufacturers. Vehicle installations have, to date, been principally on public service vehicles, and often on adequately powerful 9·6-litre engines, with the intention of raising the smoke limit or improving combustion and lessening carbon deposits rather than of saving fuel or time. An application which is arousing interest is on contractors' plant, such as excavators, where the increase in low-speed torque might allow the blower to replace an expensive torque converter. Scrapers and other vehicles, which need a high starting effort and cannot discontinue the torque to change gear, are also being studied. It is expected that the advantages of this compressor will result in engines being built to incorporate it ; those engines would probably have compression ratios and exhaust valve leads lower than those of normally aspirated units.

RAILWAY SOIL MECHANICS LABORATORY.—We have received from the chief civil engineer of the Western Region of British Railways a pamphlet describing the work of the Region's soil mechanics laboratory. Several interesting investigations have been carried out at this laboratory, some of them not directly concerned with soil mechanics, so the scope of the work there has been quite extensive. The main investigations are briefly described. They include such works as wind-tunnel tests on the formation of sand dunes, track formation investigations and notes on stabilising clay slopes by grouting. Several of the investigations mentioned have been described in this journal. The pamphlet also gives a brief outline of the history of soil mechanics and the methods of testing employed at the laboratory.

Barnes Station Accident Report

THE Ministry of Transport and Civil Aviation report has now been issued on the collision which occurred on the night of Friday, December 2nd last, on the electrified four-track line near Barnes Station in the Western Section of the Southern Region of British Railways. The collision took place when the 11.12 p.m. four-coach electric passenger train from Waterloo to Windsor and Chertsey on the down local line ran into the rear of a steam freight train, which was drawing forward after stopping at the Barnes Junction down local home signal. The electric train was travelling at about 35 m.p.h. when the collision occurred. The steel underframe of its leading coach over-rode the underframe of the goods brake van and smashed the van body and a container on the next freight wagon. The coach then turned over and a fire was started in its wooden bodywork by electrical arcing. The coach was practically burnt out and eleven of the passengers, together with the motorman and freight train guard, lost their lives. Twenty other passengers were seriously injured and twenty-one others received minor injuries. In his conclusions, following the enquiry into the accident, the inspecting officer, Lt.-Colonel G. R. S. Wilson, states that full responsibility for the collision lay with the signalman at Barnes Junction box. The Sykes lock and block system is in use on this line, and it was decided that the signalman had accepted the Windsor train by a plunge after he had used the key irregularly to reset the plunging instrument whilst the freight train was still in the section.

International Organisation for Standardisation

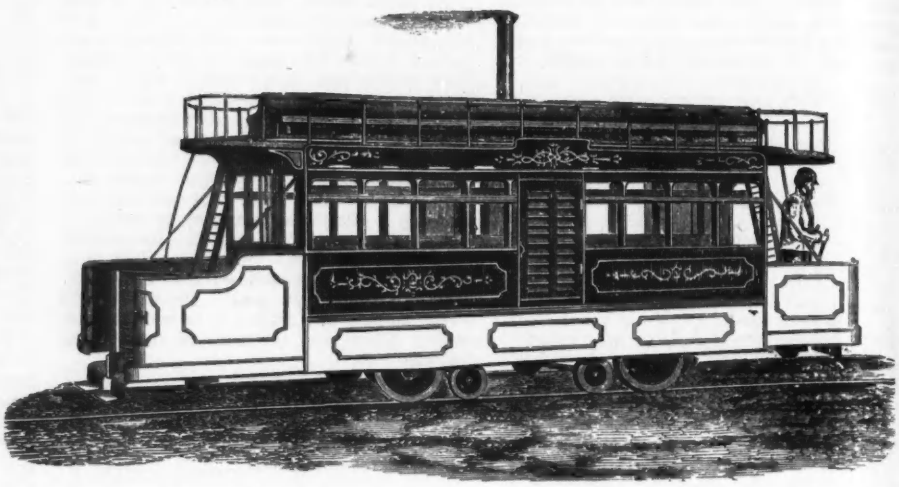
WE learn that steps to hasten the preparation of world standards in nuclear engineering and agricultural products were taken at the annual meeting of the Council of the International Organisation for Standardisation (I.S.O.)* held recently in Geneva. The I.S.O. council fully appreciates that national standards required for the peaceful development of nuclear energy should be unified internationally as swiftly as possible, both in the interests of exports and in the free interchange of scientific and technical information. Accordingly, the council decided at Geneva that its technical committees should first consider the fields of : (1) terminology, definitions and symbols ; (2) safety standards for protection against hazards from nuclear radiation, and (3) standards for the safe and effective operation of reactors. In all this work there should be close co-operation with the International Electrotechnical Commission (I.E.C.), which has formulated its own plans in the electrical field. Hitherto I.S.O. has done little work on agricultural products except for related subjects such as agricultural machinery and food containers ; but it was agreed at Geneva that I.S.O. should now give attention to those matters of urgent concern to international trade which present the least difficulties in the way of world standardisation ; they will probably include terminology, methods of test, packing, storage, handling and transport of food grains and processed foods.

The I.S.O. council also approved certain recommendations for the guidance of I.S.O.'s technical committees, including recommendations on the choice of preferred series in standards, on procedures for conversion from one system of units to another, and on the means of achieving interchangeability of products specified in different systems of measurement.

* Thirty-seven national standards organisations are embodied in I.S.O. The I.S.O. council includes the following countries : Belgium, Finland, France, Germany, India, Italy, Portugal, Russia, Spain, United Kingdom and United States. The British Standards Institution is the U.K. member of I.S.O.

ENGRAVINGS OF 1873

Mr. Grantham's "steam tramway car," which is the subject of the right-hand engraving, was first illustrated in our issue of November 28, 1873. Therein, we recorded that a trial of the car had taken place "on the tram below Victoria Station and Vauxhall Bridge" on the previous Tuesday night. A short note in the same issue says: "the boilers and engines are by Messrs. Merryweather, and the boilers failed to keep steam properly because they are too small for the work, possibly because of difficulties in firing, due to the crowded state of the car. . . . although fair promise was afforded of better things in the future." There were two boilers, "each being shut up in a kind of cupboard and no heat or smell is transmitted to the interior of the car."



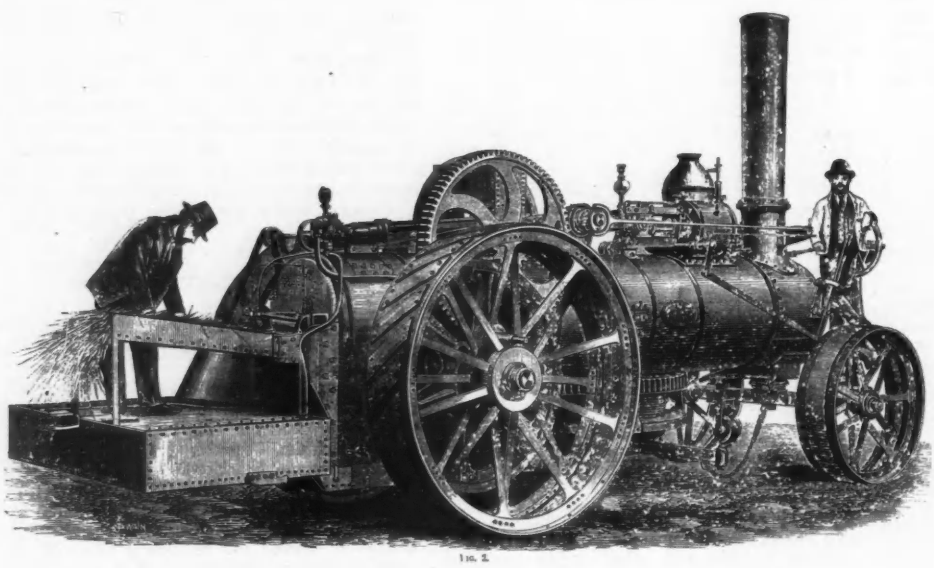
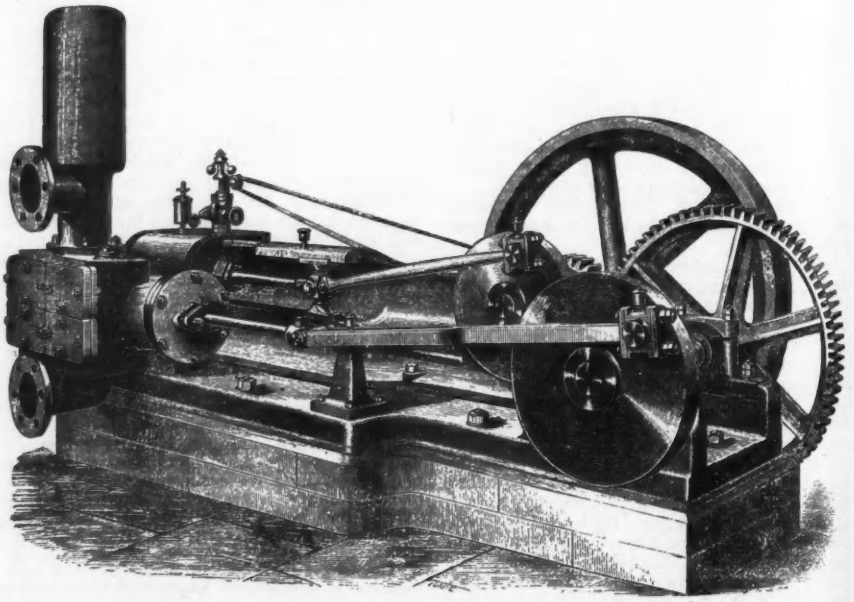


FIG. 2.

The straw-burning ploughing engine, shown in this engraving (left), was one of a pair built, for use in Russia, by John Fowler and Co., Leeds. The engines were 12 horse power. A brief description comments on "one or two modifications, the driver, as well as the steersman, standing at the front or smoke-box end, where the reversing lever and regulator are annexed." The description adds: "it is not difficult to keep up steam in a portable engine with straw, but the work done by ploughing engines is much more severe; the engine we illustrate will have to indicate about 60 h.p. Under these circumstances, Messrs. Fowler did not like to rely upon straw alone, so a tank is provided, standing across the top of the boiler, and from this petroleum can be blown in spray into the fire-box."

The "arrangement" illustrated in the right-hand engraving "shows a combination of Tangye's horizontal engine and Holman's patent double-action pump, mounted on one bed plate so arranged that all the power of the engine may be taken up by the pump, or the engine may be employed to perform other duty simultaneously." This arrangement was described in our issue of July 25, 1873. It was then stated that, hitherto, Tangye Brothers had made the engines up to 12 horse power only, but were preparing to make 16, 20 and 25 horse power engines, which, when coupled, would "carry them up to 50 horse power." The pumps, we explained, were fitted with Holman's patent buffer valves. Our article says: "these valves have proved to be very effective and durable under high pressures; it is not uncommon to put them under 500, 600, and up to 750 ft. heads of lift, and in some instances they have stood the action of this heavy pumping for two and a half years without requiring repairs."



LITERATURE

Principles of Turbo-Machinery. By D. G. SHEPHERD. The Macmillan Company, New York, 10, South Audley Street, London, W.1. Price 56s.

THIS is a very interesting account of rotative machinery operating with continuous fluid flow. The author compares different types of fans, compressors, axial-flow pumps, water turbines and steam or gas turbines on a base of energy. After a very clear introduction there is a useful chapter on dimensional analysis. The following three chapters examine the energy transfer between a fluid and a rotor, thermodynamics of gas flow and flow of fluids in turbo-machines. The specific types of turbo-machines are then dealt with —centrifugal pumps and compressors, radial-flow turbines and axial-flow turbines. A chapter then follows on the performance of turbines and comparison of types. The book concludes with a chapter on axial-flow compressors and pumps and the performance of compressors and pumps and comparison of types. The treatment is complete and balanced, and while requiring some knowledge of thermodynamics and aerodynamics, the book does give references to the many texts which can be consulted for further information. The whole book gives the impression that the author has taught the subject and therefore has the principles clearly in his mind. It should be noted that problems are given at the end of some of the chapters, mostly of an arithmetical type, but there are no answers. On the compressor work the author relies a good deal on the work of Howell at the National Gas Turbine Establishment.

The book can be recommended as a thorough and stimulating description of the underlying principles in the design of all types of turbo-machinery. The information given is up-to-date and reliable.

Wet Processes for Combating Fire-Damp and Coal Dust Explosions. By H. SCHULTZE-RHONHOF. Eighth International Conference of Directors of Safety in Mines Research, Dortmund-Derne, 1954, Paper No. 31. Translated from the German by L. MEYER. Sheffield: The Safety in Mines Research Establishment, Ministry of Fuel and Power, Portobello Street, Sheffield, 1. Price 1s. 3d.

THIS paper, from the Berggewerkschaftliche Versuchsstrecke Research Station at Dortmund-Derne, deals with two methods for binding coal dust which have been developed in Germany in recent years. Of these, one has already been described by the author at the Buxton safety conference. It consists in encrusting the coal dust with a layer of common salt, which is alternately dissolved and recrystallised. The successful application of this method depends on certain upper and lower limits of the relative humidity, and on the quantity and rate of precipitation of the dust being not too great. These limitations have been overcome in the second method, which makes use of the hygroscopic nature of calcium chloride. This by itself is found insufficient to bind the coal dust, but work at Dortmund-Derne has shown that it can be made to do so by the addition of an anionic wetting agent. The Chemische Fabrik Kalk, Köln-Kalk, has invented a method which changes the thin calcium chloride solution into a very viscous liquid, suitable for treating the sides and roof of the galleries, while previously the method was suitable only for the dust deposited on the floor. The question of airborne dust is still being investigated. With the progress now achieved, the calcium chloride method is considered suitable for preventing coal dust explosions and fires resulting from explosions of fire-damp, and it is thought will gradually supersede the method of stone dusting.

Etude Expérimentale de la Convection Forcée de la Chaleur a partir de Cylindres a Surface Rugueuse. By EDMOND A. BRUN, G. BRUNELLO and M. VERNOTTE. Publications Scientifiques et Techniques du Ministère de l'Air. No. N.T.60. Paris: Service de Documentation et d'Information Technique de l'Aeronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price 550 francs.

IN the present study of forced convection from the surface of cylinders, four tubes with their axes parallel were placed in the test section of a wind tunnel at right angles to the air stream. All tubes were of the same diameter and differed only in the roughness of their surfaces, one being smooth, and the remainder rough with different heights of the surface projections. Two sets of tubes were used consecutively, of 5mm and 8mm outside diameter respectively, and heated by means of hot water. Four identical smooth tubes were used to estimate the attainable accuracy. For smooth cylinders and Reynolds numbers Re between 6000 and 15,000, the relation $Nu = 0{\cdot}136\ (Re)^n \pm 6$ per cent, was obtained where Nu = Nusselt number, $n = 0{\cdot}61 - 0{\cdot}70$. It was found that for the same relative roughness $\frac{\varepsilon}{D}$ (where ε = height of the surface projections, D = tube diameter), the heat transfer coefficient α remained the same, and was equal to that for smooth tubes for $Re = 10{,}000 - 15{,}000$ and $\frac{\varepsilon}{D} \leqslant 0{\cdot}02$. The results for rough cylinders when plotted on a logarithmic grid, gave a number of parallel straight lines with a slope of 0·9, the lines being spaced according to the relative roughness; it was found that $Nu = 0{\cdot}0425\left(\frac{\varepsilon}{D}\right)^{0.27} (Re)^{0.9}$ for $6000 < Re < 15{,}000$.

Strömungsvorgänge in künstlich belüfteten Räumen. By W. LINKE. Forschungsberichte des Wirtschafts-und Verkehrsministeriums Nordrhein-Westfalen, No. 259. Cologne and Opladen: Westdeutscher Verlag, Ophovenerstrasse 1–3. Price DM.11·80.

OF the factors an air-conditioning plant has to deal with, the main ones are temperature, humidity and air velocity. The paper describes the forms of airflow which occur in large halls with various methods of ventilation. In the author's experiments, the airflow was rendered visible by means of smoke, showing the difference between using a few large jets and a larger number of small ones. Many model tests were carried out at Aachen, representing isothermal and non-isothermal conditions, and in the first instance dealt only with certain configurations of the room and of the air supply. In most cases the air streams passed along the ceiling, giving rise to a definite air circulation, which was investigated both qualitatively and quantitatively. In the isothermal case dynamical similarity is expressed by a law involving the Reynolds number, although experiments showed that the influence of the Reynolds number was small. Non-isothermal flow could be represented with the help of a modified Froude number, which takes a certain value when cold streams begin to sink down in warm surroundings.

Technical Explosion Investigations of Industrial Dusts. By E. WEHNER. Eighth International Conference of Directors of Safety in Mines Research, Dortmund-Derne, 1954, Paper No. 19. Sheffield: Safety in Mines Research Establishment, Ministry of Fuel and Power, Portobello Street, Sheffield, 1. Price 1s. 3d.

DR. WEHNER'S Institute, the Berggewerkschaftliche Versuchsstrecke, Dortmund-Derne, has for many years carried out work into the behaviour of industrial dusts from the point of view of the danger of explosions. In this type of work a principal difficulty arises from the fact that results very much depend on the design of the testing equipment and its application, so that some of the results obtained in special cases cannot be compared directly with similar results obtained under different experimental conditions. Three main groups of explosion-prone dusts may be distinguished, namely, "coking" dusts (coal, wood, flour, phenol resins); dusts from chemically homogeneous substances with definite melting and boiling points, which can in certain cases form vapours; and metal dusts, such as aluminium powder (this last group is rarely tested in Derne). The paper describes the various tests which are carried out at the research station.

Die Bestimmung der Frontgeschwindigkeit in einem einachsig inhomogenen Körper aus seismischen Reflexionsmessungen. By MAX Weber. Mitteilungen aus dem Institut für Geophysik, No. 26, February, 1955. Zürich: Eidgenössische Technische Hochschule, Institut für Geophysik, Leonhardstrasse 33, Zürich, 6.

IN this paper a new direct method for calculating the wave velocity $c(z)$ from the recorded travel-time curves, is developed. A comparison is made between the average of $c(z)$ and the exact average, and finally the matter is illustrated by means of a concrete example.

Books Received

Water Engineers' Handbook, 1956. Compiled by the staff of *Water and Water Engineering*, 30–31, Furnival Street, Holborn, London, E.C.4. Price 20s.

Surveying for Civil Engineers. By Philip Kissam. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 64s.

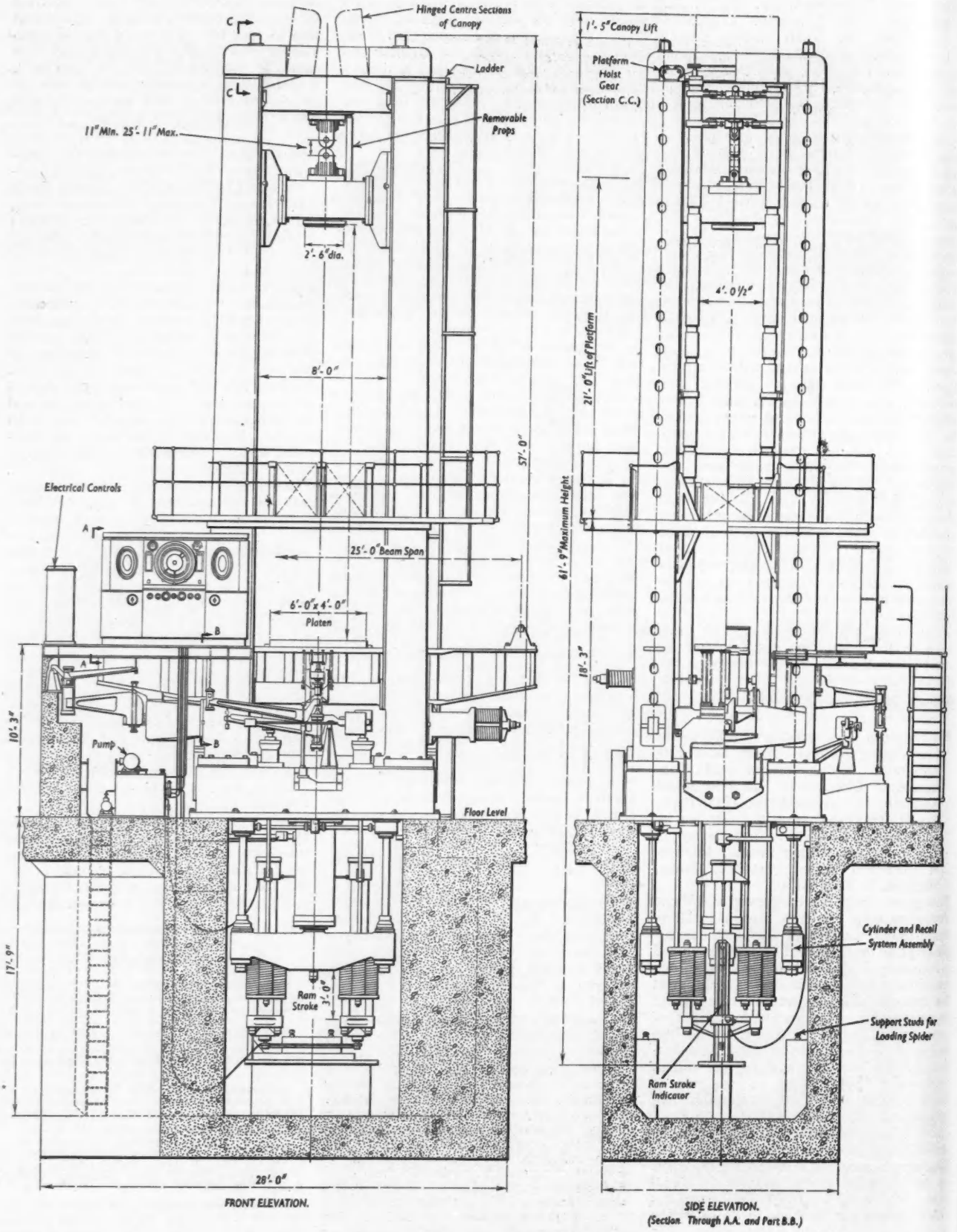
The Theory of Prestressed Concrete Design: Statically Determinate Structures. By Henry J. Cowan. Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2. Price 36s.

Solution of Problems in Telecommunications. By C. S. Henson. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 25s.

Definitions and Formulæ—Metallurgy. Fifth edition. By E. R. Taylor. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 1s. 6d.

Radio and Electronic Components. Vol. II, Variable Resistors. By G. W. A. Dummer. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 30s.

500-TON TESTING MACHINE FOR NAVAL CONSTRUCTION RESEARCH ESTABLISHMENT



500-Ton Universal Vertical Testing Machine

A large testing frame installed at the Naval Construction Research Establishment, Rosyth, was described in our issue of July 17, 1953, and we have now received particulars of a 500-ton universal testing machine supplied to the establishment by W. and T. Avery, Ltd. This new machine incorporates a number of interesting points in design for the high-precision testing of structural components. In it provision is made for measuring the lateral components of the forces on the end of a strut in addition to the vertical component of the load.

A 500-TON universal testing machine which has been installed by W. and T. Avery, Ltd., at the Naval Construction Research Establishment at Rosyth, is stated to be the largest vertical machine of its kind in the country. It provides special facilities for the high-precision tension, compression or transverse testing of large structural components and it incorporates means for the measurement of side loads set up as a result of eccentricity occurring when testing columns in compression. The machine is hydraulically operated with lever indication to an adjacent indicating unit.

The machine has four capacity ranges of 500 tons by 1 ton, 250 tons by 0·5 ton, 100 tons by 0·2 ton, and 50 tons by 0·1 ton, the side load capacity being from 0 to 25 tons in 0·1-ton increments. For tension testing purposes specimens from 11in to 25ft 11in can be accommodated between the shackles. Compression tests can be carried out on 27ft long specimens. A spherically seated 2ft 6in diameter top platen is fitted on the compression crosshead, or a 6ft by 4ft removable top platen can be used; a 6ft by 4ft bottom platen is fitted. In transverse testing the capacity is for specimens from 2ft to 25ft maximum span by 36in roller width. The clearance between the front columns is 8ft and between the side columns 4ft.

The general construction of the machine can be seen in the drawing and photographs which we reproduce. It has a cast steel base weighing some 31 tons and on this base there are bolted four vertical channel-shaped cast iron columns braced together at the top to form a rigid structure. These columns are designed to withstand side loads which may be set up in any direction during a compression test on a strut of maximum specimen length at a 1 in 20 slope. Housed in the channels of these columns are the elevating screws for a cast steel compression head guided by long shoes on the machined faces of the columns. The four elevating screws are connected at the bottom to a loading spider through which the load is applied by the downstroking main ram of the machine. For crosshead height adjustment purposes the screws are rotated through worm gearing by a 25 h.p. motor, a belt drive and slipping pulley being incorporated to protect the mechanism in the event of overrun. This crosshead has a pin-type tension shackle bolted to its upper face and when a removable 6ft by 4ft upper compression platen is fitted on the head it is supported by spring-loaded rods.

The tension crosshead situated between the columns above the compression crosshead can be seen in one of the illustrations. It is supported from the table of the machine by four vertical round struts which are guided in the fixed cast iron columns by flexure stays. These support struts are grooved at intervals for tension crosshead height setting, and the crosshead is locked in the required grooves by means of shear collars on the upper and lower faces. The shear collars are in the form of clamping jaws which are opened and closed by operation of hand levers on centrally disposed worm gear assemblies above and below the crosshead. When the height of the tension crosshead has to be altered the compression crosshead setting mechanism is used and three removable props are used to support the tension crosshead on the compression crosshead. Rollers fitted on the tension crosshead guide it on its struts during setting operations. The weight of the moving parts of the machine is supported through two hydraulic cylinders which are used to return the main ram.

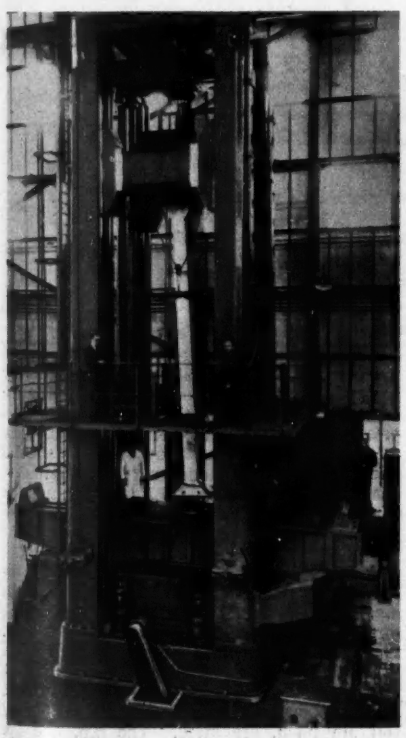
The lower compression platen and the bending beam are arranged in the form of a weighing platform for load measuring purposes. The beam is supported through flexure strips, which give it freedom of movement in two directions, and it is connected to pendulum type dial indicators which show the magnitude of the lateral load. One of the dial indicators shows the lateral load from right to left of the machine and the other the load from the front to the back. This complete laterally flexible assembly is carried on the weighing platform, which is mounted on four main levers. These levers are connected through a system of transfer levers to a pendulum dynamometer which indicates the magnitude of the vertical load on the platform.

The 36in stroke main straining ram is enclosed below the base of the machine, together with the two auxiliary hydraulic rams, which support the weight of the moving parts and also serve to return the main ram and absorb recoil when a specimen under test fractures. The hydraulic system is fed by one low- and two high-pressure pumps. The low-pressure setting pump provides fluid for supporting the deadweight of the moving parts and gives setting speeds up to 8in per minute; it runs continuously with either of the high-pressure pumps. One of the high-pressure pumps supplies fluid for straining at the maximum speed of 2in per minute to the full load. The other high-pressure pump serves as an auxiliary for straining specimens at lower speeds and is also used for load holding.

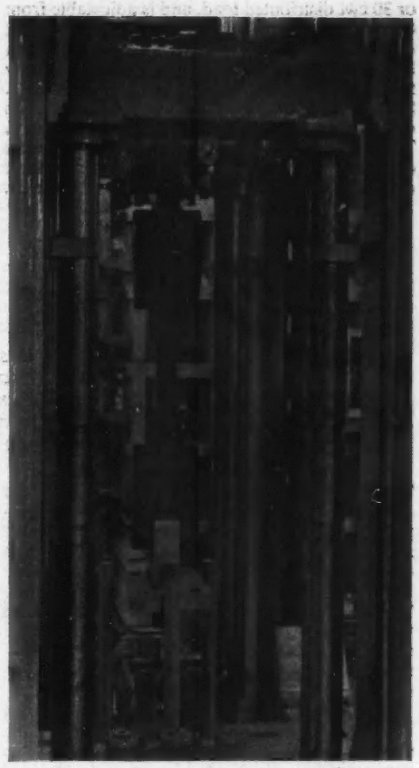
The indicating mechanism is based upon a heavy pendulum resistance and each of the four load ranges available is selected by a capacity change wheel. Operation of this wheel automatically brings the correct set of figures into view on the load indicating dial, and a deadweight mechanism attached to the wheel sets the dial to zero in each capacity. The weights of specimens are counterbalanced by a sliding tare poise fixed to the transfer lever between the load platform and the indicating mechanism. A pacing gear in the indicating equipment consists of a disc concentric with the dial rotated at constant low speeds by a geared motor. To obtain a constant rate of loading the load pointer is set to move at the same rate as the pacing disc by adjustment of the main hydraulic control valve. A load extension recorder and a load time recorder are also provided.

The main loading valve of the machine, through which the fluid from the high-pressure pumps is delivered, is designed to give a constant rate of flow for each setting irrespective of changes in pressure or variations in pump delivery. A graduated dial used to show the amount of main valve opening enables repeat settings to be made when required. One of the two unloading valves fitted can be used for removing loads from specimens at a continuous rate. The other is a fine unloading valve which is used for small load reductions, and it can be operated manually in conjunction with the loading valve for load holding when it is set to give a controlled rate of leakage from the hydraulic system. For automatic load holding a solenoid-controlled valve is fitted to work in conjunction with a high limit pointer which is set to the required loading on the dial. When in the course of a test the normal load indicating pointer contacts the high limit pointer, the solenoid valve is tripped to allow a minute quantity of pressure fluid to escape through the fine unloading valve. Means are also provided for load cycling between two predetermined limits at up to 15 cycles a minute.

To provide adequate means for observing specimens under test and access for setting purposes, a platform which is adjustable for height is built round the columns of the machine. This platform can accommodate up to twenty persons



The 500-ton vertical testing machine capable of measuring side forces due to loading an inclined strut. The observers platform can be hoisted up and down the machine



Test piece hanging from the tension crosshead. The collars locking the tension crosshead on to the columns rising from the weighing table can be seen. The head is positioned for height by supporting it on three props from the compression crosshead below

or 30 cwt distributed load, and is adjustable from 8ft above the beam of the machine over a height of 21ft. It is guided on the columns and can be locked at 12in intervals up their height by four spring-loaded pawls which engage in slots. Six drawbridges provided round the inner sides of the platform give easy access to specimens. The platform is raised and lowered through an endless hoist rope by a 1½ h.p. geared motor driving a drum below the base of the machine.

We are informed by W. and T. Avery, Ltd., that although facilities exist at Soho Foundry for the erection and testing of large testing machines, the height of this machine exceeded the height of the erection bay ; for this reason final assembly was carried out on site. A number of the large iron and steel castings used were made in Scotland and machined to the designers' requirements by Wm. Beardmore and Co., Ltd., for direct assembly on site.

Troopship "Nevasa"

The troopship "Nevasa," of 20,527 tons gross, has recently joined the fleet of the British India Steam Navigation Company, Ltd., and carries 220 first-class, 100 second-class and 180 third-class passengers and 1000 troops. A service speed of 17 knots is given by two sets of geared turbines developing 13,000 normal s.h.p. at 111 propeller r.p.m. and taking steam at 500 lb per square inch and 800 deg. Fah.

TO meet the trooping requirements of the Government, plans and designs were prepared in joint consultation by the Sea Transport Authorities, the British India Steam Navigation Company, Ltd., and Barclay, Curle and Co., Ltd. In conformity with these plans the "Nevasa" was laid down in 1953 and completed trials on July 12th, last. The ship marks the continued collaboration between the owners and the Government departments concerned, which covers a period of nearly 100 years.

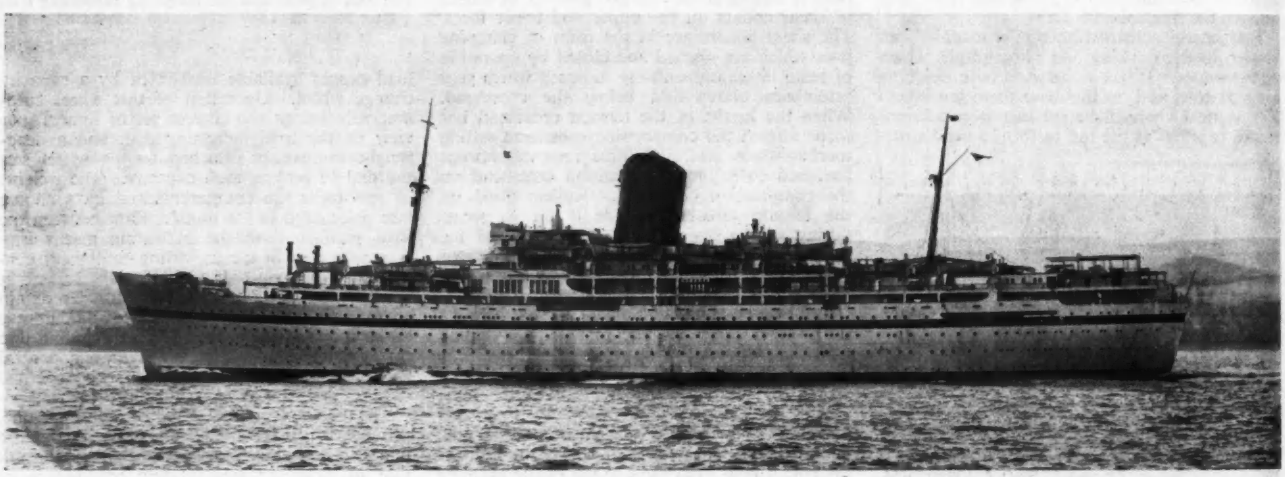
The general appearance of the ship can be seen in the photograph reproduced herewith and the ship has a length overall of 609ft, a length between perpendiculars of 560ft and a breadth moulded of 78ft, a depth moulded of 57ft to "A" deck, a gross tonnage of 20,527. She is the largest ship in the fleet of the owning company, which is in its centenary year. There are six decks, also forecastle, promenade, boat and navigating bridge decks, and accommodation is provided for 220 first-class passengers in one, two and three-berth cabins, 100 second-class passengers in two, three and four-berth cabins, 180 third-class passengers in four and six-berth cabins, and for 69 sergeants and 931 troops. A suite of rooms consisting of day room, bedroom and bathroom, is provided for the captain, and there are similar suites for the chief engineer and the ship's commandant. Cabins for the other officers are on the lower bridge deck and on the boat deck at the forward end of which is their smoking room. Accommodation for the petty officers is amidships on "C" and "D" decks, while the engine-room staff, deck crew and stewards' quarters are aft.

Public rooms for the first-class passengers are mainly on the promenade deck with the drawing room right forward and having as its main decoration a painting of Loch Ard over the fireplace. There are also the library, ladies' room, writing room with walls veneered, respectively, in Australian maple, white sycamore and bleached pommele. Corridors to port and starboard of these rooms lead to an open deck space, fitted with folding glazed screens, aft of which is the smoking room. This room has deep recesses with large casement windows, and is panelled in stripey figured olive ash. An interesting addition to the public spaces is the families' room on the boat deck. Tables for two, four or six provide seating for 206 persons in the dining saloon, which has a raised central dome, and there is a children's dining room, able to seat sixty persons. For the second-class passengers there are a lounge and a smoking room, and the second- and third-class passengers have a common dining saloon with a seating capacity of 217, and a verandah café, nursery and playing space.

Special attention has been paid to the provision of comfortable accommodation for the troops, for whom eight dormitories are arranged on "D" and "E" decks, there being separate quarters for the sergeants. Three-tier Standee beds are provided, together with individual kit bag racks and lockers, and in each space there is a cooled water drinking fountain. Washplaces and showers are located adjacent to each dormitory, and on "F" deck are spaces for storing web equipment, bedding and arms. On "B" deck is a panelled general recreation room, incorporating a combined canteen and a stage, for the troops and women's services, while there is a recreation room for men only on "C" deck. Forward on the same deck is a panelled self-service cafeteria, which can seat 306 persons, fitted with swivel chairs at long tables. A separate mess with a seating capacity of forty is provided for the sergeants.

The usual amenities are provided for the passengers and troops, and there are offices for troop administration purposes. At several points in the ship arrangements have been made so that film shows can be presented, and a generous area of the weather deck has been reserved as promenade spaces for the passengers and troops and provided with portable and permanent awnings.

Some sixty patients can be accommodated in the hospital, which is divided into eight wards and includes an operating theatre. A fully-equipped laundry is situated aft and there is also an ironing room. The refrigerating plant for the domestic cold stores consists of four electrically-driven CO_2 machines and there are also several methyl-chloride machines for dealing with cold larders and bottle lockers. "Thermo-Reg" and "Auto-Reg" heating and ventilating systems capable of maintaining an internal temperature of 70 deg. Fah. with the outside temperature at 30 deg. Fah. serve the public rooms, accommodation, galleys, laundry, &c., being thermostatically controlled in the public rooms and individually controlled in first- and second-class cabins, and cabins for the ship's officers and engineers. Thermotank, Ltd., has also supplied air conditioning for the hospital, hair-dressing saloon and the first- and second-class bureau. These units are capable of maintaining an inside condition of 84 deg. Fah. dry bulb and 70 deg. Fah. wet bulb when the outside condition is 90 deg. Fah. dry bulb, and under heating conditions can maintain an inside temperature of 70 deg. Fah. with an outside temperature of 30 deg. Fah. The total refrigerating capacity is 900,000 B.T.U. per hour. A large galley placed amidships and fitted almost entirely with electrically-operated equipment, caters for the passengers and troops, while three galleys, also all-electric and located aft, serve the crew. Other auxiliary gear includes Denny-Brown stabilisers, Scott-Ross electrically operated water-tight doors, five sewage units manufactured by Adams Hydraulics, Ltd., an automatic sprinkler and fire alarm system ; lifts for pantry service to handle baggage and for the engine-room personnel, and Drysdale's "pneupress" system. For life-saving purposes there are sixteen aluminium alloy lifeboats carried under gravity davits, and the deck machinery, consisting of a windlass, four capstans, and ten winches, are all driven by electric motors.



British India Steam Navigation Company's troopship "Nevasa"

Main and Auxiliary Machinery

Power for driving the ship is developed by two sets of triple-expansion turbines with the h.p. and i.p. turbines, of impulse pattern, driving through double reduction gearing and the l.p. turbine, of all-reaction design, through single reduction gearing. Solid manganese bronze propellers, supplied by Bull's Metal and Marine, Ltd., and having a diameter of 17ft 6in by 18ft 3in pitch, are fitted. The h.p. and l.p. astern turbines are housed in the i.p. and l.p. ahead casings, respectively. A maximum shaft horsepower of 18,400 is developed by the turbines at 125 propeller r.p.m., and at this power the ship attained a speed of about 21 knots.

Service power is 13,000 s.h.p. at 111 propeller r.p.m. and the corresponding speed 17 knots. The pumps are mainly of Drysdale's manufacture, including three centrifugal tank pattern lubricating oil pumps which discharge through two oil coolers and supply the turbines and gearing.

Four Babcock and Wilcox straight-tube boilers, fitted with superheaters and gas-air heaters, supply steam at 500 lb per square inch gauge and 800 deg. Fah. at the superheater stop valve. Two desuperheaters, one working and one standby, supply steam to the auxiliary range. The boilers have a total heating surface of 32,328 square feet, while the superheater surface is 5800 square feet and that of the air heaters is 24,280 square feet. Howden's dust collectors are fitted, one in each uptake, and the speed of emission of the waste gases from the specially designed funnel is about 100ft per minute. Howden's balanced system of forced draught is installed and maintained by four forced draught fans, each rated to deliver 21,100 cubic feet of air per minute against a pressure of 6·35in water gauge, and four induced draught fans able to deal with 31,000 cubic feet of gas per minute against a pressure drop of 5·10in water gauge. Wallsend oil fuel equipment, fitted with Drysdale pumps and having a maximum working pressure of 400 lb per square inch is installed.

G. and J. Weir, Ltd., has installed the closed feed system and the condensers, which are underslung and have steel doors lined with rubber by the Andre Rubber Company, Ltd., as an anti-corrosion measure, are capable of maintaining a vacuum of 28in when circulated with sea water at 82 deg. Fah. Each provides 52,850 lb per hour of deaerated condensate at the same temperature as the exhaust steam. There are two electrically driven extraction pumps, one working and one standby, for each condenser and each handles 104,500 lb to 136,000 lb per hour of condensate, which passes through the air ejector, glands condenser, and drains cooler, to the suction of the main feed pumps. The latter are Weir two-stage units of 272,000 lb per hour capacity of feed water, the temperature of which is raised to 300 deg. Fah. in the l.p. and h.p. heaters, when driven at 5350 r.p.m. For harbour use there is a Weir "Optimum" deaerator, fed from the main feed tank which receives all condensate drains from the turbo-generator sets. A three-stage turbo-feed pump discharges the deaerated feed water to the boiler.

For domestic needs and boiler feed 300 tons of fresh water are required per day, and to provide this there are two sets of double-effect Weir evaporating and distilling plant. Single distilled water is used for domestic use and double-distilled water for the boiler feed. Ferric chloride is injected into the system to prevent the formation of scale on the evaporator coils and to ensure the maximum heat transfer. A Weir steam generator is installed and can supply 5000 lb per hour of steam at 100 lb per square inch, the drains forming an additional source of feed make-up.

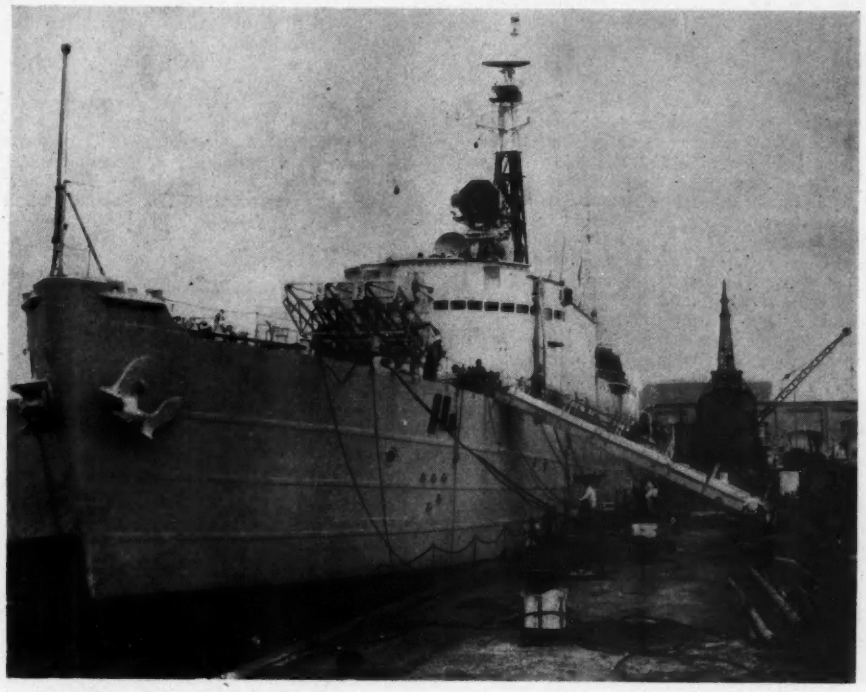
The electrical power for lighting, galley services, auxiliary and deck machinery is supplied by three 1200kW self-contained d.c. turbo-generators, constructed by W. H. Allen, Sons and Co., Ltd., in which the turbines drive the generators through Allen-Stoeckicht epicyclic reduction gearing. In addition, there is a 450kW generator, driven by a six-cylinder diesel engine, for harbour use, and a diesel-driven, 75kW emergency generator. The main units are installed in a separate generator room forward of the boiler-room. Thermotank, Ltd., has provided the ventilation system for the machinery spaces, there being four 45in diameter supply fans for the engine-room and four 50in torpedo fans for the boiler-room, while two 37½in dual torpedo supply fans ventilate the generator room, which is exhausted by two 37½in torpedo fans.

EGMANTON OILFIELD.—We are informed by the British Petroleum Company, Ltd., that eight further wells have been sunk since Well No. 1 at the Egmanton oilfield started production a year ago. Production at present is at the rate of 1000 tons a month.

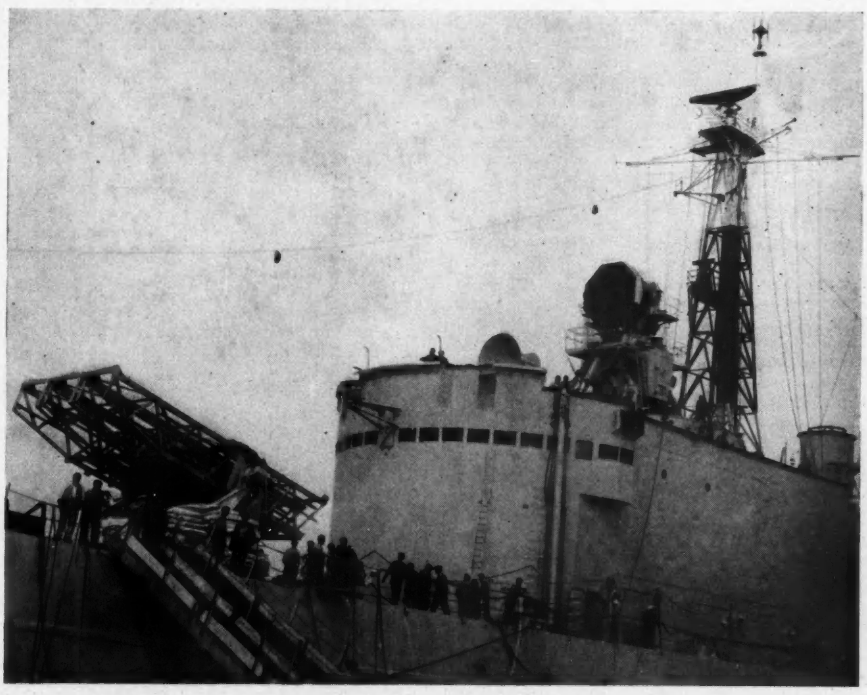
H.M.S. "Girdle Ness"

BY OUR NAVAL CORRESPONDENT

THE operational efficiency of the aircraft carriers of the United States Navy, which is being organised and trained to fight a land power from sea-air bases, has been much improved by innovations designed and produced by the Royal Navy. It is thus a matter for regret that the United States Navy is so far ahead of the Royal Navy in anti-aircraft defence. Two first-rate guided missiles have been in service in the United States Navy for a considerable time. Nine carriers have squadrons equipped with air-to-air missiles and some cruisers and smaller vessels are now armed with a ship-to-air missile. The Royal Navy, on the other hand, is only now ready to test out a ship-to-air missile designed and developed in this country. Britain started late in the race for guided missiles, but it was realised in the early stages that a special ship would be required for sea trials, and in 1953 H.M.S. "Girdle Ness"—a maintenance vessel—was selected for the role and completely stripped and recon-



H.M.S. "Girdle Ness" was originally a landing craft maintenance ship. She has now been commissioned as a guided missile trial ship



H.M.S. "Girdle Ness": the guided missile launching platform and electronic gear are visible

structed in Devonport dockyard. A ship of 10,000 tons, with the hull of a "Victory" type merchant ship, she was built in Canada as a landing craft maintenance ship and was commissioned for her new duties on July 24th. The Americans converted an old battleship and a seaplane tender four or five years ago for trials of both offensive and defensive missiles, but the "Girdle Ness" was considered entirely suitable for the trials which we required, and more economical to run than a converted warship. The Admiralty will make no forecast of the duration of the trials beyond stating that a prolonged period of firings is required whose nature and duration must inevitably depend on the success of the earlier firings and the amount of information obtained from them. The 1955 Defence White Paper indicated that the design of the new guided weapon ships for the Fleet was under way, but as the laying down of these vessels depends on the results of the "Girdle Ness" trials there seems but a faint hope that provision for even one ship of cruiser type will be made in next year's Estimates.

The "Girdle Ness" was commissioned last week. As reconstructed—see illustrations on page 163—she now has a large, square superstructure superimposed on which is a tangle of radar masts and aerials of great variety. The guided weapon equipment in fact consists of radars, displays and communications equipment to enable a target to be selected and to control the missiles in flight, magazines and handling gear for stowing and transporting the missiles, and, finally, a triple mounting launcher. In addition, there are elaborate facilities for obtaining instrumental data from the trials. The missile launcher, which is immediately before the bridge, can be trained and elevated and is fitted with tracks up which the missiles travel. The missiles come from their magazines on rails and are rolled through flash-tight doors between decks to the launching site. Below each of the ramps of the launcher is a flash-tight hatch through which the missiles are raised by hydraulic power. The radar equipment in the stern of the vessel is similar to the radar equipment in aircraft carriers for giving bearings, heights and long-range warning. Data for the missiles will be transmitted to the apparatus which controls them by a more accurate, shorter range radar. On the foremast are the conventional navigational radar and the radar which automatically follows the target and along which the missile is made to fly. Presumably this is the "beam riding" system now in use for the United States Navy's ship-to-air missile "Terrier," which has a range of at least 10 miles.

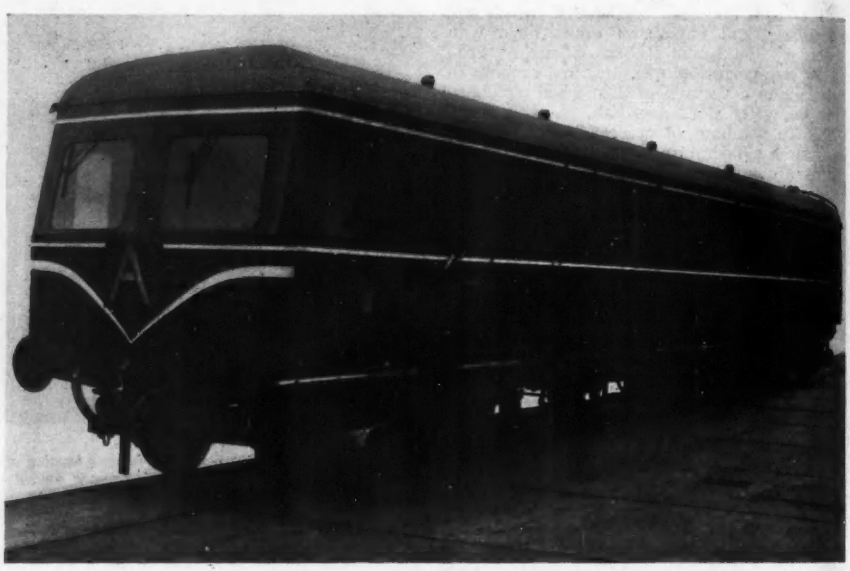
The new missiles now to be tested have been developed at the Ministry of Supply Research Establishment at Aberporth in Wales, and at the Weapons Research Establishment in South Australia. Many of the personnel responsible for the research development will be associated with the sea trials and accommodation has been provided in the "Girdle Ness" for officers of the Royal Naval Scientific Service, and for representatives of the Admiralty, the Ministry of Supply, and the firms who made the equipment. With a normal complement of thirty officers and 370 men, the ship now has accommodation for eighty officers and 536 men. After embarking the missiles and doing her sea trials, the "Girdle Ness" will proceed to the Irish Sea for training her ship's company in handling the pilotless aircraft—or "drones"—which are to be used as targets wireless controlled from the ship. During the various trials, considerable attention will be given to tactical problems and to the degree of protection afforded by guided missiles against attacks both by formations of bombers and simultaneous attacks by single bombers from several directions.

CRANE MANUFACTURER'S LABORATORIES.—A new laboratory has been laid down by Steele's Engineering Products, Ltd., Sunderland, for testing the materials used in the construction of the firm's mobile cranes. The five main departments of the new laboratory are equipped for mechanical, chemical and metallurgical testing, foundry sand control and general research in new materials.

Inter-City Diesel Railcars

The first of a number of multiple-unit diesel trains for inter-city services on British Railways was recently completed at the Swindon works of the Western Region. These trains, with a top service speed of 68 m.p.h., are made up of powered and trailer cars which can be arranged in three- six- or nine-car sets.

A NEW design of multiple-unit diesel train has been developed by British Railways for main line service between certain principal cities, and the first of the new trains has just been completed at the Swindon works of the Western Region. These new diesel trains have been built to the same standards of strength and comfort as the main line coaches in use on British Railways, and one of the new powered cars can be seen in the illustration on this page. Two types of powered cars are being built for the trains—motor brake second class and motor second class. The motor brake second-class cars have an open passenger saloon with seating accommodation for fifty-two persons, a driver's compartment, a combined guard's compartment and luggage van, and two toilets. The motor second-class cars provide seating accommodation for sixty-two passengers in two open saloons, a driver's compartment and toilet accommodation. Two types of trailer cars are built for first-class accommodation, one with seven compartments for forty-two passengers, and the other having a buffet and accommodation for eighteen passengers in three compartments.



Motor brake second-class inter-city diesel railcar

The cars will normally be formed in trains of three, six, or nine cars, each three-car train consisting of two powered cars with a trailer car between. Certain of the power cars are built for leading vehicles, having one end without gangway connections, and a large driver's cab extending the full width. The other cars have gangway connections at both ends and a small driver's compartment set on the side at one end. This design of car is intended for an intermediate position in a main train, but is used as a leading vehicle when a train is split into three-car sets.

All the cars, which are 64ft 6in long and 9ft wide at the waist, are fitted with Buck-eye automatic couplers and Pullman gangways. They have been designed to resist an end compression load of 200 tons in the same way as the standard locomotive-drawn corridor stock. Unlike the existing standard stock, however, these cars are of "stressed body" construction, the underframe, body sides and roof combining to form a welded structure which resists all bending, compression and draught stresses. This form of construction is particularly useful for diesel cars, since the underframe is completely free from conventional trussing, and makes available the maximum possible space below the floor of the car for the suspension of the diesel and auxiliary equipment, giving adequate room for maintenance purposes.

New lines have been laid down at Swindon works for building the coaches, which are of all-welded construction, the underframe being fabricated from rolled steel sections on to which is welded a corrugated steel floor of special section, which considerably increases the resistance of the vehicle to end shocks. The body sides and ends, formed of pressed steel framing members, with outside panelling of 16 gauge steel, are jig-built in sub-assemblies. The lower section of the roof panelling is formed of 8 gauge plate, which, when all the sub-assemblies are welded together into a complete vehicle, forms a continuous structural member extending the full length of the coach. The whole of the interior of the body sides, ends and roof is insulated with sprayed asbestos: the corrugated steel floor, besides having the underside treated with sprayed asbestos, also has the corrugations on the top completely filled with the same insulating material, on which is fitted the floor surface of insulating hardboard. Trap doors are provided at various places in the floor, to facilitate inspection and maintenance of the diesel equipment.

The bogies have a wheelbase of 8ft 6in and are of riveted construction, using rolled steel sections and fabricated sub-assemblies. The rolled steel disc wheels, 36in in diameter, are fitted with Timken roller bearing axleboxes having manganese steel liners. During the construction of the bogies special attention has been given to the alignment of the hornguides, which are also fitted with renewable manganese liners. After the assembly of the bogie side plates and cross members the complete bogie frame is mounted in a jig and the four horn gaps are machined. This ensures that the foundations for the manganese liners are perfectly square one with the other and that the liners can be quickly renewed when necessary without the use of shims. The side plates are carried on laminated steel springs with

rubber auxiliary bearing springs, while the bolster is mounted on nests of helical springs carried on suspension bolts hung from the bogie frame on spherical bearings. Lateral movement of the bolster is damped by a large Woodhead-Monroe hydraulic shock absorber, and to reduce the noise which may be transmitted from the track to the coach body, the centre and side bearings are both mounted on rubber. Automatic vacuum brakes are fitted to all vehicles.

Power Equipment

All the power equipment has been supplied by British United Traction, Ltd., two engines with transmission and auxiliary equipment being mounted below the floor on each power car. The engines are of the A.E.C. six-cylinder, horizontal type, with a maximum output of 150 h.p. at 1800 r.p.m., and are fitted with 18in fluid flywheels. A short cardan shaft and free-wheel connects the engine to a four-speed "R.14" Wilson gearbox, which carries pulleys at either end for the belts driving the exhausters and electric generator, the latter being on the output side of the gearbox. A further cardan shaft connects the gearbox to the forward and reverse final drive, mounted on the inner axle

Driver's cab of inter-city diesel railcar

of the bogie. Each engine has its own cooling system, with header tank and fan cooled radiator driven through a right-angled drive from the front of the engine. The throttle, gearbox and final drives are electro-pneumatically operated, the electro-pneumatic valves being grouped together in boxes carried on the underframe: the compressed air is fed from storage reservoirs supplied by air compressors mounted on the engine. The control equipment is so arranged that a maximum of six power cars can be operated from any driving cab, which would be the normal number of powered cars in a nine-car train. The electrical control circuits are carried between adjacent cars by means of four nineteen-point flexible jumper couplings.

A driver's cab is shown in our second illustration. By the operation of one starting button all the engines on the left-hand side of the train can be started up, while a second button starts all those on the right-hand side. Indicator lights show when each engine has started, and if an engine subsequently stops for any reason the failure of one indicator light shows the exact position in the train. The operation of one button stops all the engines. Indicator lights are provided to indicate when sufficient air pressure is available in each power car and that the final drives are correctly positioned for starting. A dead man's handle operates the throttle, and when it is released, besides closing the throttle, it also applies the brakes. Other equipment on the control tables of the driver's cabs comprises the gear change control handle, vacuum brake valve, and controls for dual-note warning horns and windscreen wipers. A hand-brake wheel is fitted in close proximity to the driver's seat, and on the cars intended for service on the Western Region, that region's automatic train control equipment will be fitted below the hand-brake wheel. Instruments grouped together in a suitable position for observation by the driver include gauges which indicate compressed air pressure, high and low vacuum in the two-pipe brake systems, train speed and engine speed. Fuel tanks of 90 gallons capacity are designed to enable the trains to run up to 900 miles without refuelling. The trains have a maximum service speed of 68 m.p.h.

An adjustable leather-padded seat is provided for the driver, and a leather-padded arm rest is conveniently placed for the driver when operating the dead man's handle. Warm air from the main heating system is fed into the driver's compartment, and, if necessary, warm air can be diverted on to the windscreen for demisting purposes. Fire protection equipment, fitted above all the engines, automatically discharges chlorobromomethane from a spray tube on to the engine if a pyrotechnic cord mounted above the engine is subjected to excessive heat. Operation of the fire protection equipment shuts down the affected engine and rings a bell in the driver's compartment. The position of the affected engine in the train is indicated to the driver by its indicator light, which goes out, and a warning light also appears at the side of the vehicle, showing the location of the fire from track level.

A light and modern decorative scheme has been adopted for the open saloons in the motor vehicles; they are panelled in plastic, the walls and ceilings in "Formica" grey luxwood, contrasting with the doors and partitions for which "Formica" matt mahogany has been used. Tubular luggage racks of anodised aluminium which run the complete length of the saloon, on either side, have small electric light fittings on the underside of the rack, immediately above each nest of seats. General illumination is provided by large circular fittings in the ceiling. The seats, of tubular construction, are fitted with "Dunlopillo" cushions and backs and are upholstered in cut moquette. The first-class trailer cars have a finish generally similar to that on British Railways standard first-class coaches.

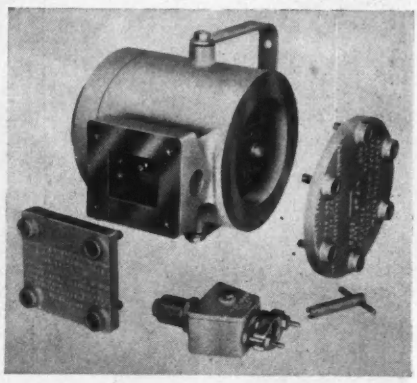
Each car is heated by two oil-fired air heaters mounted under the floor, and the warmed air is conveyed through ducts to the interior of the vehicles. To meet the requirements of both the open and compartment types of cars, different arrangements of temperature control and air distribution are used. In the first-class trailer cars a temperature control handle is provided near the heater control panel in the vestibule. This equipment is under the control of the guard who, by operation of the handle, can determine the proportion of fresh or recirculated air supplied to the heaters. Air ducts with discharge apertures are arranged under each compartment seat and, by the use of controls, passengers can independently control the supply of warm air.

In the case of vehicles having open saloons, warm air from the heaters is passed through ducts to the inside of the car, where it is conveyed along both sides at floor level and discharged through apertures below the seats. To provide general control of the temperature inside these cars, the operation of the heaters is controlled by a thermostat situated inside the saloon, but passengers may exercise further control by the operation of a temperature control situated on the partition of the saloon, which regulates the proportion of fresh and recirculated air supplied to the heaters. In warm weather, all the heaters may be switched off and filtered air, at ambient temperature, circulated throughout the car.

The first trains of this new stock will be placed in service between Edinburgh and Glasgow, and later ones between Birmingham and Swansea, and for these services forty-three power cars and twenty-one trailer cars are being built. We recently attended a demonstration run in one of the new trains between Swindon and Paddington. The distance of just over 78 miles was covered in seventy-three minutes with one signal check, at which the speed and smoothness of acceleration were very noticeable. The riding qualities of the stock were particularly good at all speeds, and the standard of comfort in both the first and second-class accommodation should make the trains popular with the travelling public.

Flameproof Loudspeaker Driving Unit

An extension of the industrial applications of audio broadcasting for staff announcements and similar messages has been made possible by the introduction of a new flameproof loudspeaker horn driving unit. It is designed and made for use in inflammable atmospheres by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2, and is the first equipment of its kind to receive the Ministry of Fuel and Power's certificate approving its use in atmospheres covered by Groups II and III of B.S. 229/1946, for flameproof equipment. It is designed to provide loud, intelligible speech in those sections of the oil, paint and chemical industries, for example, where direct sound



Exploded view of flameproof horn loudspeaker driving unit. It has a maximum capacity of 10W and a frequency response of 200 to 7000 c/s

broadcasting has hitherto been impossible because of the risk of fire or explosion.

The driving unit is a pressure-operated device suitable for use with a projector horn or any well-designed re-entrant horn having a minimum air column length of 20in. The speech coil and driver section, the magnet assembly and the line matching transformer are all totally enclosed in a substantial aluminium alloy cast flameproof case, an "exploded" view of which is illustrated here.

Maximum reliability is ensured by the enamelled copper wire on the speech coil winding with beryllium copper lead-out strips. The multi-ratio transformer provides various line impedances between 600 ohms and 30,000 ohms; the power fed from the loudspeaker line to any unit may thus be individually adjusted to suit varying site conditions. The maximum power-handling capacity is 10W and the frequency response is 200 to 7000 c/s ± 3 db.

East Anglian Gas Grid.—A new gas grid covering 125 miles in Suffolk and Essex, in the supply area of the Eastern Gas Board, was completed last week. The grid extends from Chelmsford in the south-west, through Colchester and Ipswich, to Saxmundham, Leiston, Thorpeness and Aldeburgh in the north-east, with branches to several towns and villages *en route*. More than 95,000 consumers will receive their gas through this grid system, which will be supplied from three major works at Chelmsford, Colchester and Ipswich. With the completion of this grid it has been possible to close twelve of the smaller, less economic works; some of the twenty-six towns and villages supplied from the grid will receive a gas supply for the first time. The scheme has cost some £500,000, but it is estimated that it will result in a saving of £84,000 a year in production costs alone.

Test House for Grinding, Screening and Filtering Equipment

For the solving of grinding, screening and filtering problems arising from the demands of industry for specific raw materials, International Combustion, Ltd., has a test house at its Derby works. In the house is installed a full range of machines of commercial size for experiment and research.

AT the Derby works of International Combustion, Ltd., a wide variety of machines and equipment are manufactured to serve directly or indirectly a number of diverse industries, such as steel, pottery and glass, plastics, mining and quarrying, and electric power generation and the production of building materials, chemicals, food and paper. A tour of the works amply demonstrated the extensive range and variety of workpieces passing through the machine shops and the wide range of casting which the foundry is called upon to produce. Cast iron is mainly used and the maximum weight of casting produced is about 18 tons. With regard to the foundry, it was of interest to note the automatic weighing arrangements for supplying raw materials to the hot blast cupola and the machine moulding section for batch production, together with the conveyor system for cooling the castings which incorporated an automatic trip to deliver faulty castings to the scrap bay. New drying ovens, of the company's own design, have been installed which are flue-gas-fired, the combustion products being delivered by a fan through nozzles for circulation in the oven.

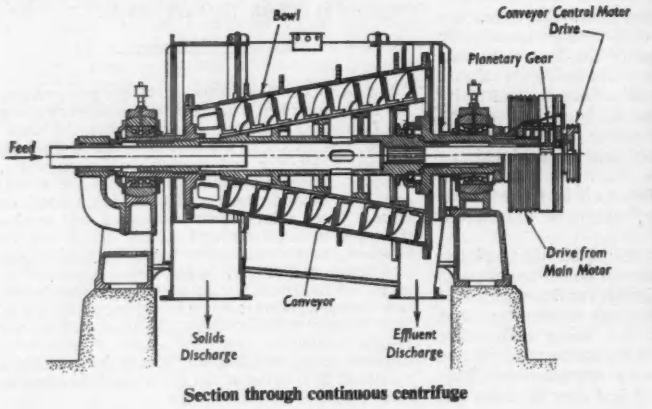
The principal purpose of the visit was to inspect the test house, which is an integral part of the company's grinding, screening and filtering division, which produces a range of equipment to meet the requirements of industry. The grinding equipment, part of which can be seen in our illustration, includes "Hardinge" conical ball mills, "Lopulco" mills and "Raymond" roller, and "Impax" mills, and for screening there are "Hummer" electric and "Tyrock" mechanical vibrating screens, while for filtering there are "Rovac" rotary vacuum and disc filters and the "Dynocone" continuous centrifuge.

Interior of test house with "Lopulco" mill in the foreground

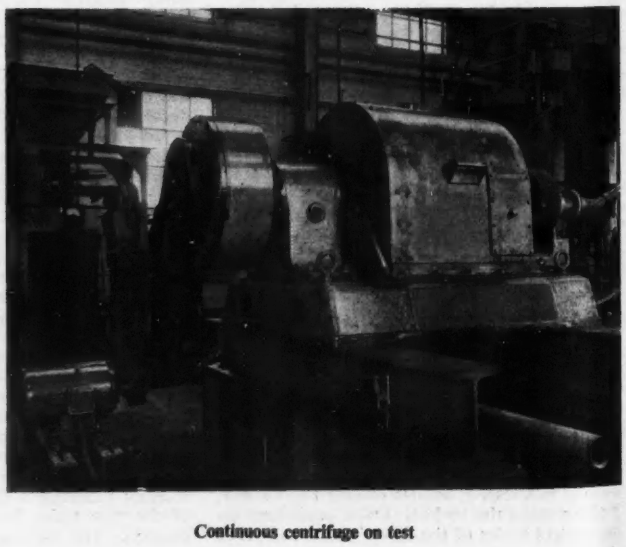
However the fitness for purpose, adaptability, performance and production costs are matters which require to be closely examined if the utilisation of the earth's raw materials is to be economically realised. The properties of raw materials vary widely so that a variety of physical and chemical processes are necessary in order to prepare the material for use in industry. In view of this it is necessary to study the behaviour of the raw materials, under different conditions, in order to determine the correct process and technique to produce a particular end product. Allied to this is the need to estimate, from the results achieved from tests on sample consignments, the size of equipment and associated technical information required for full-scale production. This is the function of the test house, which is equipped with a full range of machines of the smallest sizes commercially available, including pulverising mills, air classifying equipment, vacuum filtration plant, continuous centrifuges, hydraulic classifiers, pumps to handle solids in suspension, vibrating screens and feeders. The plant is broadly arranged in two sections, one for dry and the other for wet processing. Data are being compiled steadily and the results of many thousands of tests have been placed on file to form a central pool of technical information for the ready solution of problems. Thousands of specimens of materials are stored in the sample room, the raw material being linked with the industrial product required such as limestone to rubber filler, titanium oxide to superfine pigment, coke to electrodes, phosphate rock to fertilizer.

With the grinding equipment available in the house and suitable speed adjustment to suit soft, abrasive or medium hard materials it is possible to reduce the softest or the hardest materials to powders of a consistently high degree of fineness, the particle size being very often 0·002in diameter, and occasionally as small as 0·0005in diameter. Dry grinding operations are always carried out in an air circuit at a pressure below atmospheric to ensure that there is no emission of the product, a requirement which is essential when toxic or other injurious materials are being handled. In wet grinding, where classification is effected hydraulically, it is necessary to separate the water from the product and this is done in a thickener and rotary vacuum filters. Research in the test house establishes the degree of filterability, the size of gauze required, the amount of air, the amount of material which can be passed per square foot per hour, and what form of discharge should be employed.

However, all materials are not filterable, and to overcome this difficulty a new machine, the "Dynocone", has been added to the range of equipment. It is a continuous centrifuge and operates on the principle of accelerated settlement and is not equipped with filter cloth or screens. The machine discharges a product of a high degree of dryness, depending upon particle size, provided that the material has good settling



Section through continuous centrifuge



Continuous centrifuge on test

properties, and an effluent containing very little solid content. The essential parts of the machine, of which we reproduce a line drawing, consist of a horizontal revolving frusto-cone-shaped shell housing a screw conveyor which rotates at a slightly higher speed.

The bowl is driven by a main motor, whereas the conveyor is carried on the output shaft of a planetary gearbox which rotates with the bowl, while the input shaft is coupled to a conveyor control motor. A speed difference between the gearbox input shaft and the machine provides relative movement between screw and bowl. This arrangement solved the problem presented by the high frictional forces between the solids and the bowl surface set up by centrifugal action and the high torque required to turn the conveyor to remove the solids. Due to the relative speed between bowl and conveyor, the power required is small. No relative movement of screw and bowl takes place with the machine revolving and the control motor circuit open. However, with the circuit closed and the machine on load the friction between screw and bowl, due to the removal of solids, produces a generated current in the control motor circuit which increases as the load is increased. When the torque set up in the machine approaches a value likely to damage the gearing, the motor is tripped by a current overload device. An electrical interlock between the conveyor control and the feed pump motors automatically regulates the feed or can cut it off if overload occurs.

The centre tube of the conveyor admits the feed, which must be of fluid consistency, to the bowl and imparts angular momentum, which imposes a high centrifugal force on the solids in suspension. Thus the solids settle on the surface of the bowl, the liquid meanwhile assuming a solid of revolution. At a predetermined level the liquid overflows to discharge ports at the large end of the bowl, while the solids which have been progressively dewatered by the centrifugal forces are discharged at the small end. The process was demonstrated in the test house when a saturated solution of ammonium sulphate was gravity fed to a "Dynocone" and ammonia crystals having a moisture content of less than 1 per cent were recovered and a clear liquid discharged. "Dynocones," one of which is shown on test in our illustration, are manufactured in two sizes, 36in by 50in. and 24in by 24in, the respective weights being 3·5 tons and 1·5 tons, the material used being mild steel or stainless steel for the working parts and cast iron for the bed-plate.

Several of the machines in the test house were demonstrated, including the "Vacseal" pump and a variety of mechanically and electrically vibrated screens, and the "Syntron" vibrator-energised spiral elevator. Apart from applied research, other work on fundamental principles is being carried out, and it was of interest to note the experimental work touching upon the effect of combustion gases on boiler tubes. This work has shown that the higher temperatures of present boiler installations has resulted in the catalytic production of sulphuric acid when combustion products pass over heated iron surfaces.

A well-equipped chemical and physical laboratory forms an integral part of the testing facilities and is available for special investigations into matters concerning particle size analysis, settling rate of suspensions, filterability and the many other problems which arise from industrial demands for specific materials. For particle size measurement there are available the microscopic count, air permeability, sedimentation, elutriation, and light extinction methods, while the flocculation method for removing finely divided powder in suspension in an effluent was demonstrated. The laboratory controls the metallurgical quality of the manufactured products, and for this purpose is equipped to carry out spectroscopic analysis and also X-ray, gamma-ray, and ultrasonic examinations.

SUMMER SCHOOL IN HIGHWAY ENGINEERING.—A "summer school" in highway engineering is to be held at the University of Birmingham next September and November. It consists of a week of lectures and discussions in each of these two months, the long interval between the two being introduced to help in the release of staff by firms and public authorities. Recent developments in the theory and practice of highway engineering will be discussed at the school.

Electrical Drive for a Flour Mill

REPLACEMENT of forty-three-year-old steam engine drives by electric motor drives forms the basis of improvements recently carried out at the flour mills of Cranfield Brothers, Ltd., Ipswich. This modernisation scheme was originally projected soon after the recent war, but the change was deferred because it was necessary to keep the mills in operation for at least 160 hours per week and it was impossible at the time to guarantee an uninterrupted power supply. By 1951, however, it was felt that the electricity supply industry was in a better position to maintain regular supplies, free from load-shedding and the company decided to proceed with its plans for the changeover from steam drives.

Because flour milling is essentially a continuous process effected by machines which have to be started up and run simultaneously, it was decided to replace the two existing steam engines (one of which is shown in Fig. 1) by two large auto-synchronous motors in preference to a large number of smaller motors. Each of the two main mills was therefore to be driven by an auto-synchronous motor, an arrangement which would simplify the task of maintaining the overall electrical load at or near unity power factor.

The motors and the associated switchboards and transformers referred to below were supplied by Crompton Parkinson, Ltd., who carried out the contract for the changeover in conjunction with the Ipswich district of the Eastern Electricity Board and the engineering staff of Cranfield Brothers, Ltd.

The provision of a high-voltage supply for the machines was simplified by the existence of a 6·6kV feeder already installed along a route adjacent to the premises. Because of the need for continuous operation of the mills, however, the Eastern Electricity Board installed a metering panel and two feeder switches to provide duplication of supply. From the board's busbars the

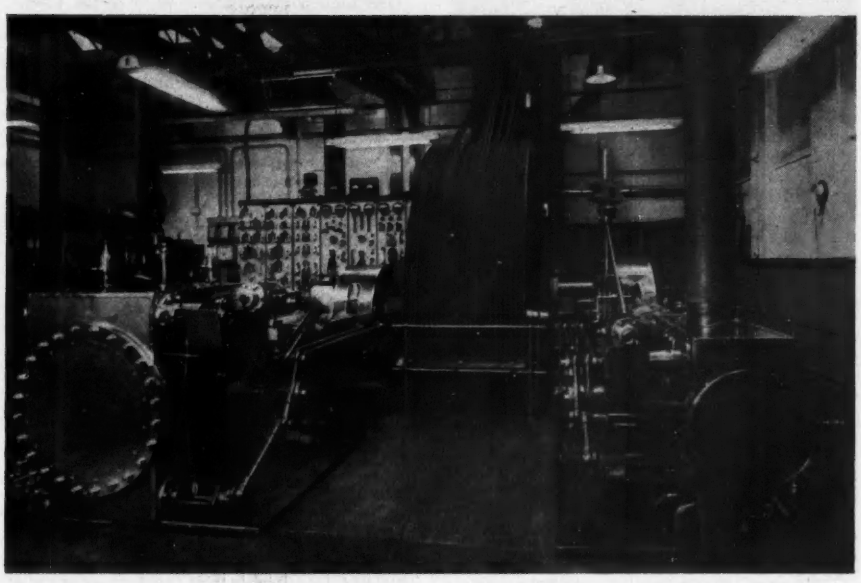


Fig. 1—700 h.p. steam engine drive for No. 1 flour mill at Cranfield Brothers, Ltd. The drive was transmitted by a 16ft diameter flywheel pulley, via twenty-four 1¼in cotton ropes

Fig. 2—The new drive for No. 1 mill is 700 h.p. auto-synchronous motor with a 4ft diameter pulley. On the left is the control desk. In the background are the 750kVA transformer and the switchboards

6·6kV supply is taken to a four-panel "ALA/ASA" switchboard of 250MVA rating at 6·6kV, erected in the No. 1 mill.

The consumers' h.v. switchboard comprises an incoming unit, a stator switch for the No. 1 mill auto-synchronous motor, an isolator through which a h.v. supply is taken to a stator switch in No. 2 mill for the second auto-synchronous motor, and a circuit breaker which controls the supply to a Crompton Parkinson 750kVA transformer. This transformer provides 415/240V supplies to two l.v. switchboards which control feeders to the l.v. equipment throughout the mill, including various motors and the lighting circuits. One l.v. switchboard is installed with the h.v. switchgear in No. 1 mill control room and consists of "Klad" circuit breakers, switch fuse units and an isolator, the latter providing a l.v. supply to the second "Klad" switchboard which is installed in the No. 2 mill control room.

The auto-synchronous motors are rated at 700 h.p. and 400 h.p. for No. 1 mill and No. 2 mill respectively, the machines having sufficient capacity to cater for future expansion at the mills. Both machines are designed to run at 333 r.p.m. and have barring gear driven by a separate slipring motor. Both motor drives are accommodated in the existing engine houses, the motors being installed as far as possible on the appropriately modified engine foundations to give the best driving arrangements with the minimum of alteration to the existing drives, the control desks, liquid starters and barring gear being sited to give the operators a full view of the rope drives during starting.

The 700 h.p. motor in No. 1 mill (Fig. 2) is a Crompton Parkinson "AX" machine with pedestal bearings and a flexibly-coupled exciter on a combined bedplate. The main driving pulley, located between two pedestal bearings and flexibly coupled to the motor shaft, has a P.C.D. of 48·65in and twenty-six grooves for 1⅜in "Dixel" ropes. By comparison, the original drive had to have a flywheel pulley diameter of 16ft because of its relatively low speed.

The control desk for the motor is supplied with remote control facilities for opening and closing the spring-operated stator switch, and an Allen-West hand-operated liquid starter, fitted with safety interlock, is installed next to the control desk. Also on the control desk are "stop," "start" and "inch" buttons for the 25 h.p. slipring motor that drives the barring gear, together with instruments to indicate main motor current and power factor, and a regulator to control the exciter field, whereby the operating power factor of the motor can be adjusted according to the load conditions on the mill. Besides being controlled from the control desk, the auto-synchronous and barring gear motors can also be stopped from emergency "stop" buttons located on each floor of the mill. A similar arrangement is used in No. 2 mill for the 400 h.p. motor, but in this instance the motor has a driving pulley of 50in P.C.D. with fourteen grooves for 1⅜in "Dixel" ropes.

With auto-synchronous motors providing the main drives the power factor of Cranfield's load is being maintained at 0·98 lagging. This high power factor, in conjunction with a high load factor, has resulted in very economical running. With a maximum demand of about 1200kVA and a yearly consumption of approximately 5,700,000kWh, the consumer is saving about 220kVA per year, which would represent about £1000 per annum for electricity compared with consumers having a similar load, but at 0·8 power factor lagging.

PHOTOTHERMOELASTICITY.—In view of the difficulties associated with studies of thermal stresses under transient heating conditions, as experienced by aircraft accelerating to great speeds, interest attaches to a Note on Photothermoelasticity in the July, 1956, *Journal of the Aeronautical Sciences*. The authors, George Gerard and Arthur C. Gilbert, have used photoelastic techniques to investigate transient stresses which were imposed, to avoid creep, by refrigeration. A series of three fringe photographs are reproduced; the authors expect to study a wing structure under thermal and static load.

Transformer Coolant for High Temperatures

TRANSFORMER loadings may be increased either by improving the cooling system or by accepting a higher temperature rise. With oil-cooled transformers the permissible temperature limit is of the order of 120 deg. Cent. above which transformer oils generally become unstable and the possibilities of other liquid coolants may be worth considering.

One such coolant, known as "Aroclor 1248," is stable at temperatures considerably higher than 120 deg. Cent. and tests are being done by Monsanto Chemicals, Ltd., London, S.W.1, to determine the temperature limits that can be tolerated by this liquid. The results derived from these tests, to date, have been given in an interim report published by the company. Here we give abstracts from the report in which it is stated that it is possible to operate at coil temperatures of 120 deg. Cent. and that there are prospects that a maximum temperature might be tolerated.

PROPERTIES OF "AROCLOR 1248"

The breakdown strength of "Aroclor 1248" (as recived from the manufacturing plant) was measured in accordance with B.S. 148 with a 3mm gap; a constant value of approximately 60kV over a temperature range from room temperature to 150 deg. Cent. was found. The power factor at 1000 c/s rose to 0·015 at 150 deg. Cent. and volume resistivity at 500V per millimetre was $1·6\times10^{11}$ ohm cm. Whilst these last two values are slightly below normal for the customary transformer coolants, the breakdown strength is shown to be fully maintained under these conditions.

Temperature/Load Relations.—A single-phase, 240/240V transformer was built to operate at high temperature. It consists of 230 to 238 turns of 16 s.w.g. silicone-bonded glass fibre-insulated copper wire with a "Ferrosil 92" shell type core. It is equipped with thermocouples to measure temperature in the middle of the core and windings and at the surface of the coolant.

This transformer was run while blanketed on various loads and the temperatures in the middle of the core, the middle of the windings and at the surface of the coolant were examined. These are set out in Table I. It is immediately apparent

TABLE I

Load	Temperatures, deg. Cent. Top of fluid	Core	Coil
1·0kVA	67	81	83
1·2kVA	81	95	99
1·4kVA	103	111	121
1·6kVA	116	128	142
1·8kVA	127	152	163
2·0kVA	146	162	188

from the tests that a considerable increase in load could be tolerated even though with these runs the transformer was blanketed.

Insulation.—A problem that was encountered in running this transformer was the solvent resistance of the insulation. The coils were insulated with silicone-varnish-bonded glass fibre and such varnish had been shown to be resistant in 100 deg. and 150 deg. Cent. tests. However, temperatures of 200 deg. Cent. were achieved on some occasions and the silicone bonding was plasticised and partly dissolved. A more detailed investigation was therefore started.

Bonded glass fibre tape may be used as insulation for coils and attention was therefore directed to materials suitable for bonding. Three were considered: silastomer, phenolic resin and polyurethane resin. Tests consisted of exposing short lengths of glass fibre tapes, bonded with these materials, to "Aroclor 1248" maintained at 180 deg. or 200 deg. Cent. for one week. At the end of that time the tapes were tested for tensile strength and the "Aroclor" was examined for ionic impurity by volume resistivity tests.

It was soon apparent that complete curing of the polymers was essential. For silicone rubber this consisted of treatment at 250 deg. Cent. for twenty-four hours. The phenolic-resin-bonded glass was at first aged at 135 deg. Cent., although in later work a curing temperature of 180 deg. Cent. for one week was adopted with better results. Polyurethane was also aged at this temperature. The results of ageing at 180 deg. and 200 deg. Cent. are shown in Table II whence it appears that the silastomer is the most resistant of these materials, although it cannot be said to be completely so. Core plates with Kaolin insulation were aged for one week at 200 deg. Cent. in "Aroclor 1248" and no change was observed in fluid.

Temperature Rise on Switching On.—It was thought that a danger might exist that on cold start-up at full load the transformer would become overheated. Therefore a metal vessel containing mercury was heated with capsule heater, while immersed in "Aroclor 1248" and other coolants. It was seen that the temperature/time relation for the mercury was linear for at least a minute and independent of the nature of the coolant; there was no sign of initial overheating. It was shown quantitatively that this initial slope was that expected from the heat capacity of the system assuming no cooling of the system. Data for a normal 500kVA unit were then examined, and it was found that, assuming no heat losses, the transformer would rise to 120 deg. Cent. in 1½ hours—ample time for the "Aroclor 1248" to heat up.

The only danger arising from low-temperature start-up is if the fluid has frozen and contraction voids have occurred. In such a case, it is possible that internal discharge could occur in the vacuum so formed. However, the pour point of "Aroclor 1248" is −10 deg. Cent. and cavitation does not occur above −20 deg. Cent.

Use of a Scavenger, "R.D.7051."—In the event of arcing in the fluid some hydrogen chloride will be dissolved in the fluid, as with all chlorinated hydro-carbon fluids. For this reason tetraphenyl tin has been used dissolved in "Aroclor 1248" as a scavenger to remove it.

TABLE II

Material	Area of material	Quantity of "1248"	Ageing period	Temp., deg. Cent.	Vol. res. of fluid at 200V d.c. and 100 deg. Cent.	P.F. of fluid at 1000 cycles and 100 deg. Cent.	Condition of material	Remarks
None	—	100 ml.	7 days	(*a*) 180	$2·2\times10^{12}$ ohm cm	0·0026	Control	—
				(*b*) 200	$2·2\times10^{12}$ ohm cm	0·0021	Control	—
Silastomer-bonded glass fibre	3in long × ¾in wide	100 ml.	7 days	(*a*) 180	$2·7\times10^{12}$ ohm cm	0·0020	No change in strength	Slight turbidity in 1248 on cooling
				(*b*) 200	$2·5\times10^{12}$ ohm cm	0·0021	No change in strength	Slightly greater turbidity in 1248 on cooling
Polyurethane-bonded glass tape	Two pieces, 3in long × ¾in wide	100 ml.	7 days	(*a*) 180	—	—	Considerable darkening of fluid	Air-aged specimens aged at 200 deg. Cent. in Aroclor
				(*b*) 200	$3·0\times10^{10}$ ohm cm	0·027	Fluid discoloured	—
Phenolic resin bonded glass tape	Two pieces, 3in long × ¾in wide	100 ml.	7 days	(*a*) 180	—	—	Considerable darkening of fluid	Air-aged specimen aged at 200 deg. Cent. in Aroclor
				(*b*) 200	$1·1\times10^{12}$ ohm cm	0·0042	No change in strength	Fluid appeared clear

This fluid, containing the scavenger, is known as "RD.7051." It is stable up to 150 deg. Cent., but if the hot-spot of the transformer is above this temperature the tetraphenyl tin decomposes after a time. Therefore, "Aroclor 1248" alone should be used at the higher temperatures. Hydrogen chloride will be even less soluble in "Aroclor 1248" at high temperatures than at low temperatures; the gas only attacks metals in the presence of moisture and the likelihood of this attack will be much smaller at these temperatures than at normal temperatures; further, no cellulosic insulation will be present.

Future Work.—It is intended to wind a transformer with anodised aluminium wire in which the anodised surface layer serve as insulation and has already been found to be resistant to "Aroclor." Although its conductivity is less than that of copper, its favourable temperature coefficient reduces the difference. It is therefore sufficient to use, for example, 14 s.w.g. aluminium in place of 16 s.w.g. copper to obtain the equivalent circuit. The volume occupied is actually no more, since the anodised surface is much thinner than any resistant wound-on insulation. It is anticipated that the temperature rise in the middle of the winding will be lower with aluminium than with copper.

Survival at Sea

BY OUR NAVAL CORRESPONDENT

FROM a study of the records available of the war at sea, 1939–1945, it was estimated that between 30,000 and 40,000 officers and men lost their lives due to drowning. Deaths due to drowning represented about 66 per cent of the total naval casualties, and the Admiralty decided soon after the end of the war to set up a Committee to consider all aspects of naval lifesaving. One of the earliest of the Committee's recommendations was the inflatable life-raft, which is now the standard item of lifesaving equipment in H.M. ships. The familiar Carley Float will disappear entirely over the next few years. The Carley Float is inherently buoyant and might seem at first glance more effective for lifesaving purposes, but this has been disproved in practice. They are well secured in ships and it has not always been possible to release them in emergency. Even if they have been launched or have floated off a ship in cold waters, survivors reaching them have been liable to death from chilling in the partially immersed condition or from drowning in the cold-induced stupor while on the float. The inflatable life-raft, on the other hand, affords protection from all weathers and climates. When stowed in ships, it presents a small target area and is not liable to damage from the shock of an explosion. It can be launched with ease if the need arises.

The life-raft has not yet been fitted in all ships, but several versions which are developments of the basic design are in service. Two sizes are available—a large size with a nominal carrying capacity of twenty men (overload to twenty-seven); and a smaller one with a nominal carrying capacity of eight men (overload to ten). The larger size, oval in plan, consists basically of a large buoyancy tube which supports a double-skin floor on which are fitted air cushion seats. Bridging the buoyancy tube are two inflatable arched thwarts which support a double-skin tent cover. Inflation is achieved by the use of one or more gas bottles. The raft, deflated, is folded and stowed in a canvas valise. Further improvements are expected as a result of research now in progress. Maintenance is one of the biggest problems. But, while stowed in ships, they will be disturbed as little as possible other than for the periodical check weighing of the inflation cylinders. Complete outfits will be exchanged at intervals of not longer than three years, which means a high annual turn-over of stocks. Apart from the minor repairs within the capability of the naval store staff, it will be necessary for some time to come to make use of contract organisations for the major overhauls. A survival pack is being developed as part of the life-raft's equipment.

While the inflatable life-raft has been under development attention has also been paid to the needs of the shipwrecked in the shape of personal equipment. Lifejackets are intended not only to assist the non-swimmer but also to keep the exhausted or injured swimmer afloat and as safe as possible until he can be picked up by rescue craft. The ideal lifejacket should incorporate many well-defined characteristics, not all of which were apparent in the sausage-type inflatable lifebelt issued to all officers and ratings during the second world war. The new kind of inflatable jacket, which has now been in service for some time, is made of rubberised cotton fabric and shaped to fit round the neck of the wearer and rest on his chest. Fitted with a light, a whistle and toggle and line, it is inflated orally through a mouthpiece and non-return valve. When deflated, the jacket is stowed in a canvas pouch fitted to a stout webbing belt.

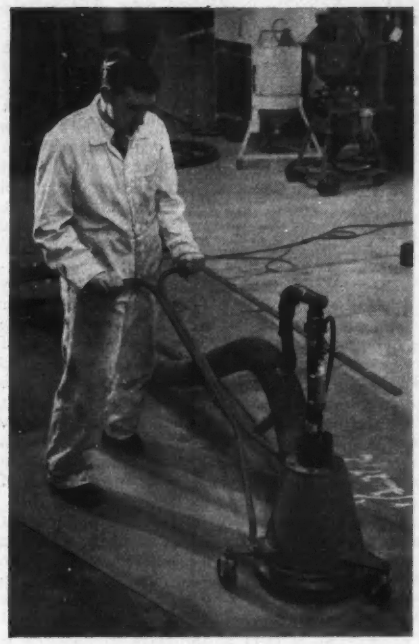
The rescue of survivors from sunken submarines presents many problems which have formed the subject of an article in these columns. Investigations by the Admiralty Committee showed that as many men escaped from submarines during the war by making "free ascents," without any apparatus at all, as with any form of breathing apparatus. The Committee accordingly recommended that submarines built in the future should be equipped with an escape chamber into which each man could enter in turn and rise to the surface by "free ascent." The Davis submarine escape apparatus would no longer be used. The Committee also established that the main danger to life was not during the ascent from the submarine, but during the period inside the submarine before escaping while the compartment was being flooded up to equalise the pressure. No less than three-quarters of the casualties in a submarine accident occur during this period as the result of CO_2 poisoning, or of oxygen poisoning when wearing the Davis escape apparatus and breathing pure oxygen. No flooding-up will be necessary in future submarines with an escape chamber, but in the hope of avoiding this danger in existing submarines, which have no room for an escape chamber, they are to be fitted with a built-in breathing system at each end of the vessel. This consists of large bottles containing a mixture of 40 per cent oxygen and 60 per cent nitrogen, with a tube and mouthpiece for each man. Provision is also made for each man to have a submarine escape immersion suit and a modified version of the standard inflatable lifejacket.

Blast Cleaning Equipment for Large Plates

A RECENT addition to the blast cleaning equipment made by Vacu-Blast, Ltd., 291, Aberdeen Avenue, Slough, Bucks, is a mobile high-production gun specially designed for the rapid removal of millscale from large flat plates lying horizontally on the ground prior to fabrication. The gun operates on a similar principle to other "Vacu-Blast" equipment in which a blast of abrasive material is directed from a nozzle on to the work surface. This nozzle is situated in an enclosed chamber under vacuum, and after impinging on the work the abrasive, together with any dust, rust or scale is drawn up through the annular space between the nozzle body and the inner wall of the surrounding chamber.

The new gun is used in conjunction with one of the firm's "Senior" machines incorporating the vacuum unit, abrasive supply and recovery and dust removal equipment; externally all that is required is a supply of compressed air and electrical power. In standard equipment 25ft long air and vacuum hoses connect the gun with the machine, but additional hose lengths of 50ft can be supplied if required. The gun normally works with air at a pressure of 80 lb to 100 lb per square inch and 11in vacuum.

The gun can be seen in use on a small demonstration plate in the accompanying illustration. Its conical cabinet head is supported on castors providing sufficient height to give effective contact between the annular ring of sealing bristles on its lower face and the plate. Fitted in the top of the cabinet is a rotating assembly of three ¼in blast nozzles driven by a small air motor. As the ring of nozzles rotates a stream of abrasives covering a diameter of 8in is directed on to the surface of the plate below. This arrangement enables an 8in wide track to be cleaned along a plate at each pass of the gun, and the makers state that millscale can be removed at an average rate of 300 to 600 square feet per hour, depending upon the condition of the surface to be blasted. As the abrasive cleans the plate it is picked up, together with scale and



Hand propelled shot blast cleaning equipment removing scale from a plate

dirt, by the vacuum, and returned to the machine, where the debris is removed before the abrasive is recirculated.

The new gun can be propelled by hand as illustrated, or a small air-motor-driven traction unit can be fitted in place of the front castor. This traction unit is reversible and the operator needs only to exert sufficient effort to guide the gun by the handles during return passes over a plate. To enable the equipment to clean right up to the edges of plates narrow levelling strips can be placed along the sides.

The maker points out that with this type of plant there is no danger of free abrasive or dirt being discharged to the surrounding atmosphere, and plates are left in a clean condition ready for painting, welding or other processing. The new guns are also easily adaptable for carriage mounting on traversing frames in special-purpose plants where the cleaning of plates *in situ* on a floor is not possible.

Congress on Irrigation and Drainage

THE International Commission on Irrigation and Drainage is to hold its third congress in May, 1957, at San Francisco, United States. The congress will be concerned principally with the discussion of four topics as follows:—question 7, canal linings; question 8, soil and water relationship in irrigation—this subject includes study of the movement of water in irrigated soils, the preservation of soil structure and fertility, and the economical use of irrigation water; question 9, hydraulic structures on irrigation and drainage systems; question 10, the interrelation between irrigation and drainage. Communications on the six "questions" discussed at the previous two congresses will also form part of the congress proceedings, all the papers for which have now been submitted to the commission. The congress will be followed by study tours to water conservation works in California and in other parts of the United States.

Industrial and Labour Notes

British Steel Home Demand

The quarterly review of the British Iron and Steel Federation states that during the first part of this year, although the home market has been supplied with finished steel at a rate more than 10 per cent higher than in the first half of 1955, the demand is still excessive as a result of the general inflationary situation. Consumers' purchases of steel at nearly 15 per cent higher than a year ago have outstripped actual usage, and a very sharp rise has taken place in consumers' stocks. Despite government measures to check the boom and continued pressure on steel supplies the quantitative result on the general demand for steel is small as yet. The report points out that there has been a reduced demand for some metal consumer goods, but investment expenditures, which account for more than three-fifths of the home demand for steel, continue at an enhanced rate.

In 1955 steel production increased by 1,250,000 tons to 19,800,000 tons and a further increase of 1,250,000 tons is expected in the current year. The output in the first months of the year was fully up to the amount required to meet a higher target ; the full benefits of new developments in blast-furnaces will be felt throughout 1956. Development schemes now in progress are outlined in the review, and it is considered that on the basis of plans already in hand the industry expects a production of 23,500,000 tons of steel by 1958.

Dealing with raw materials, it is pointed out that such a great expansion in capacity in the near future will bring about a renewed concern over raw material supplies. An analysis of scrap supplies shows that 52 per cent of the home supply arises automatically in the course of production of steel in the form in which it is delivered, and 30 per cent more is in waste from re-rolling and processing industries. The remaining 18 per cent is mainly from domestic scrap collection. This domestic source of supply of scrap, it is stated, could be considerably increased by the use of effective ferrous scrap recovery equipment at local refuse destructor plants, and steps have been taken by the steel industry and scrap merchants to avoid this source of wastage of valuable material. There is also a problem in iron ore supply to be faced with the rising steel production and there is, states the report, a likelihood that the proportion of the industry's ore requirements drawn from abroad must be increased.

World Steel Production

The quarterly review of the British Iron and Steel Federation also contains a report on world steel production, which in 1955 reached the record total of more than 265 million tons, some 45,500,000 tons more than the previous year. Of this increase the United States was responsible for 25,700,000 tons, but it is pointed out that this rise reflected a recovery from the sharp fall in output in 1954 rather than in an increase in capacity. The steel producing regions and their 1955 outputs were as follows :—United States, 104,500,000 tons ; the Commonwealth, including the United Kingdom, 29,710,000 tons ; Western Europe (including Britain), 58,620,000 tons ; Soviet group, 58,660,000 tons ; Latin America, 2,100,000 tons ; and other countries, 11,890,000 tons.

Prices Stabilised by I.C.I.

In a statement declaring its agreement with the policy of price restraint advocated by the Federation of British Industries, the board of Imperial Chemical Industries, Ltd., announces its intention of making no further increases in home trade prices of a number of its products until June 30, 1957. The products particularly concerned include chemicals, dyestuffs, explosives, fertilisers, fibres, paints, pharmaceuticals, and plastics. The prices will be stabilised over the period stated provided no unexpected or exceptional factors intervene and provided the company does not incur any major increase in the cost of freight or fuel before the date mentioned. In making the announcement the firm points out that as a direct consequence of its policy of increasing productive efficiency in combination with price restraint, the weighted average of the company's home trade selling prices has advanced by only two-thirds during the ten years since 1946, although the Purchase Price Index for the company's raw materials has increased to two-and-a-half times the level in 1946, and over the same period the I.C.I. index of earnings per employee of all grades has doubled. The production costs of certain of the company's products, particularly those involving non-ferrous metals, depend upon imported raw materials which fluctuate widely in price, and for these products it is pointed out the firm can do no more than continue its policy of price restraint.

Inquiry into the Dock Labour Scheme

The report has been published of the committee of inquiry (Cmd. 9813, price 3s. 6d.) appointed by the Minister of Labour and National Service in 1955, under the chairmanship of Mr. Justice Devlin, to look into the operation of the dock labour scheme and to advise what alterations, if any, should be made in it. The committee states that its main business proved to be the consideration of the proposal that the principle of joint control by both sides of the industry should be altered. Joint control was the essence of the existing scheme and Mr. Bevin, who introduced it, firmly believed it would in the end bring peace and satisfaction to the docks. The reasons why the committee considered that this principle should be retained are set out in detail in the report. The committee was not authorised to inquire into the industry generally so that it did not investigate a number of complaints of restrictive practices, the cost of labour and inefficient work in the ports.

The report finds that after eight years' working there is much to be put to the credit of the scheme and none of the grave unrest that has occurred can be put down to any provision of the scheme that has turned out to be unworkable. But it expresses disappointment that the Board has not matured into a more positive force and has not made a greater contribution towards curing the malady in the industry. It goes on to express the hope that if the report is accepted, the employers will embrace the spirit of the scheme (as they have already accepted it in the letter) as an association of equal partners pooling their ideas for keeping the labour force contented and happy. It insists, however, that if the employers will embrace the scheme in this spirit it is imperative that the trade union leaders should meet them more than halfway. The trade union leaders proposed no means of dealing with the problem of unrest and have given the committee, as well as the employers, the impression that they have not sufficiently considered whether there are any such means. The report insists that sacrifice of powers must be mutual, and as the unions have been given a share of the management of labour, which in ordinary industry belongs to the employers alone, so they should admit the employers to a share in the functions and duties which in ordinary industry belong to the trade union alone. The committee suggested that there should be a renewed attempt to settle the troubles of the industry ; a new and more powerful spirit of co-operation giving a wider field of agreement on policy could enrich the work of the Board so that it became a positive force for good. It also points out that as a means of educating the dock worker as to his responsibilities the Board is in a better position than either the employers or unions alone.

National Industrial Fuel Efficiency Service

The second progress survey and report of the National Industrial Fuel Efficiency Service for the year ended March 31st last shows that there was a substantial expansion in the demand for its services. A total of 12,509 visits were made to factories by engineers under the service and of these visits 7578 were made under the first-aid service. Heat and power surveys were carried out in 495 works, whilst the number of regular service agreements increased from seventy-eight to 262 during the year. Under the education scheme over 700 boiler operators were trained in courses for a City and Guilds certificate. The fact that the peak of demand for N.I.F.E.S.' services does not appear to have been reached is creating financial problems for the board, and the report of the directors shows that the call upon sponsors during the year under review was for over 95 per cent of the sums that they had guaranteed. For this reason development would depend upon attracting a greater income from industry. The only fees received were for the heat and power surveys and the regular service agreements, and even those fees did not cover the whole of the cost involved. The report points out that it is only by securing greater revenue that an effective service, capable of showing the ways to fuel economies and maintaining a high standard of efficiency, could be provided for the additional fuel users who required it.

Gas Industry Statistics

The Gas Council has issued statistics relating to the gas industry for the twelve months ended March, 1956. During that period the industrial sales of gas increased by 4 per cent and domestic sales fell by 1 per cent ; the total sales of gas showed an increase of 1 per cent over the financial year 1954/55. Production of coal gas in the twelve months rose by 2·2 per cent, against an increase of 1·7 per cent in the quantity of coal carbonised. Water gas production fell by 14 per cent and the amount of materials used in water gas making, viz., coke, gas oil and heavy oil, also fell by approximately 14 per cent. In the twelve months the quantity of gas made in oil gasification plants increased by 17 per cent, and the heavy oil used in these plants amounted to 4,200,000 gallons, compared with 3,600,000 gallons in the previous year.

Coke production increased over the twelve months ended March, 1956, by 3 per cent, and the sales throughout the period remained about the same as in the previous year. The amount of coke breeze made fell by 2 per cent over the period, whereas the production of crude tar and crude benzol increased by 2 per cent and 1 per cent respectively. New gas making capacity of 40,000,000 cubic feet, which was brought into use in the first three months of 1956, made the total of new plant brought into use in 1955/56 up to 104 million cubic feet, compared with a total of 137 million cubic feet in 1954/55. An increase of 523 miles in the length of new mains laid between January and March, 1956, brought the total mileage of new mains laid during the twelve months ended March, 1956, to 2475 miles.

Manpower in Industry

Last week we published on this page a brief résumé of the employment situation in 1955, as revealed by the annual report of the Ministry of Labour and National Service. Some further information, extending into 1956 and giving some details of the trend of employment in different branches of industry is given in the July issue of the *Bulletin for Industry*, published by the Treasury. It is pointed out that although civil employment has risen by nearly 1,500,000 since 1948, vacancies still exceed the number unemployed ; however, in the last few months there has been a slight easing in the demand for manpower. During the first five months of 1956, industrial production and civil employment were steady ; both were rising fast in the same period of the two previous years. Some industries have shown, during the early part of 1956, a decline in the numbers they employ. They are, principally, those concerned with wireless valves and apparatus, motor vehicle manufacture, cotton and furniture. Basic industries have increased, seasonally, by about the same amount as last year, but there has been a small drop of 38,000 in the total working population. There were 100,000 workers on short time at the end of May, but unemployment is still very low. In conditions of changing demand, the *Bulletin* points out, it is an acceleration of the normal processes of labour movement, rather than any new process, which occurs.

India's Second Five-Year Plan

BY OUR INDIAN CORRESPONDENT

India's first five-year plan (THE ENGINEER, *January* 23, 1953) *was essentially a programme for increased agricultural production. That aim having been achieved, it has now been decided to broaden the industrial base of the country's economy and accelerate the rate of increase of national income. The second plan will increase the per capita income from Rs.*280 *to Rs.*330 *in five years, an increase of roughly* 18 *per cent as against that of* 10 *per cent over the first plan period. Total outlay will be of the order of Rs.*7000 *crores, of which more than half will be allotted to engineering industries and transport. The plan came into force on April* 1, 1956.

THE second five-year plan, an extension of the first plan ended on March 31, 1956, has for its principal objectives (1) a sizeable increase in national income so as to raise the level of living in the country ; (2) rapid industrialisation with particular emphasis on the development of basic and heavy industries ; (3) a large expansion of employment opportunities ; and (4) reduction of inequalities in income and wealth and a more even distribution of economic power.

India's national income was Rs.255* *per capita* per annum at the beginning of the first plan in March 1951. Five years later it increased by 10 per cent to Rs.280. The increase during the next five-year period is expected to be of the order of 18 per cent when the *per capita* income will be Rs.330. Table I indicates the increases in national product and income of industrial origin during the first and second plan periods. If the rate of increase in the subsequent plan periods is maintained at the above level, it will be possible to double the national income by 1967-68, that is, in about twelve years' time.

TABLE I—*Net National Product by Industrial Origin*

	(Rs. Crores at 1952-53 prices)				
				Percentage increase	
	1950–51	1955–56	1960–61	During 1951–56	During 1956–61
1. Agriculture and allied pursuits	4,450	5,230	6,170	18	18
2. Mining	80	95	150	19	58
3. Factory Establishments	590	840	1,380	43	64
4. Small enterprises	740	840	1,085	14	30
5. Construction	180	220	295	22	34
6. Commerce, transport and communications	1,650	1,875	2,300	14	23
7. Professions and services	1,420	1,700	2,100	20	23
Total National Product	9,110	10,800	13,480	18	25
Per Capita Income (Rs.)	255	280	330	10	18

PLAN OUTLAY AND ALLOCATIONS

Table II gives the plan outlay by major heads of development. The total outlay will be Rs.7300 crores* of which Rs.4800 crores will be a direct state responsibility and the remaining Rs.2500 will be the investment in the private sector. This is almost double the outlay on the first plan, although the emphasis has now shifted from agriculture and social services to transport and industry. A little under half the amount will be spent on transport and industrial expansion, the expenditure on transport (and communication) being almost a third of the total plan outlay. This shift had been envisaged in the first plan : the advance in agriculture, irrigation and power achieved under it has prepared the ground for a substantial advance in industry. The Planning Commission presided over by Mr. Jawaharlal Nehru, the Prime Minister, has been very clear and unambiguous on this point of rapid industrialisation. In its report, it says : " Rapid industrialisation is the core of development. But if it is to be rapid enough, the country must aim at developing industries which make machines to make the machines needed for the large number of industries in the field of consumer goods and intermediate products. India's known natural resources are relatively large, and in many of these fields, as in steel for instance, she is likely to have a comparative cost advantage. It is desirable to aim at proceeding farthest in the direction of developing heavy and capital goods industries which conform to this criterion."

A tentative estimate of financial resources required to carry out the plan is given in Table III. It will be seen from this that of a total of Rs.4800 crores needed in the public sector, only a half can be raised in the country through the usual channels of revenue and capital formation. It is proposed to meet the gap by resorting to deficit financing and partly through foreign assistance. External assistance can be in the form of aid or investment. During the first plan, foreign investment averaged about Rs.40 crores per year, but prospects of a substantial increase are said to be favourable for the coming five-year period. Aid is also expected from quarters other than European and American. A number of trade agreements have recently been signed with countries behind the iron curtain, many of which, including Soviet Russia, are taking a keen interest in Indian industrial development for the first time in their history. The gradual relaxation of international tension is also expected to contribute to expansion in trade and, consequently, in surplus revenue. Although, therefore, the gap of Rs.2400 crores sounds enormous, the planning authorities are hopeful that, barring a severe trade depression or deterioration in international climate, the general upward trend in world economy augurs well for the raising of the necessary finance from the world markets.

TABLE II—*Plan Outlay by Major Heads of Development*

	First five-year plan		Second five-year plan	
	Total provision	Per cent	Total provision	Per cent
	Rs. crores	Rs. crores	Rs. crores	Rs. crores
I. Agriculture	372	16	565	12
II. Irrigation and power	661	28	898	18
(*a*) Irrigation and flood control	395	17	458	9
(*b*) Power	266	11	440	9
III. Industries and Minerals	179	7	891	19
(*a*) Large-scale industries and minerals	149	6	691	15
(*b*) Small-scale industries	30	1	200	4
IV. Transport and Communications	556	24	1384	29
(*a*) Railways	268	12	900	19
(*b*) Roads	146	6	265	6
(*c*) Shipping	58	2	100	2
(*d*) Communications	84	4	119	2
V. Social Services	547	23	946	20
VI. Miscellaneous	41	2	116	2
Total	2356	100	4800	100

TABLE III—*Financial Resources*

	Rs. Crores
1. Surplus from Current Revenue (mainly taxation)	800
2. Borrowings from the Public (market loans and small savings)	1200
3. Other budgetary sources	400
4. External assistance	800
5. Deficit financing	1200
6. Uncovered gap*	400
Total	4800

* This may be raised through deficit financing if other means are not available.

INDUSTRIES AND MINERALS

The expansion of industrial capacity during the second plan is conceived in terms of the following priorities : (1) development of iron and steel production, machine-building, heavy engineering and heavy chemicals ; (2) expansion of capacity in respect of other developmental commodities and producer goods, e.g. cement; (3) modernisation and re-equipment of industries already in existence, viz. jute, cotton and sugar ; (4) fuller utilisation of installed capacity in existing industries wherever there are wide gaps between capacity and production ; and (5) expansion of capacity for consumer goods. Table IV gives the estimated production and targets set for some of the engineering industries under the plan.

Three new steel plants of 1,000,000 tons ingot capacity each will be established in the public sector at a cost of over Rs.400 crores. The plant at Rourkella (with German collaboration and technical assistance) will produce flat steel products and is designed to operate the L.D. process. The Bhilai plant in Madhya Pradesh (with Soviet financial and technical aid) will turn out mainly heavy and medium products including billets for the re-rolling industry. The third plant to be set up at Durgapur (with British financial and technical assistance) in West Bengal will make light and medium products. The existing plants are also to be expanded : the Tata plant at Jamshedpur will double its capacity to 2,000,000 tons of ingot steel. Other heavy engineering projects include a heavy steel foundry at Chittaranjan for meeting the requirements of railways for heavy castings, forge shops and heavy structural shops under the auspices of the National Industrial Development Corporation, a heavy electrical plant (with technical assistance and consultation by A.E.I. and English Electric) with a capital of about Rs.40 crores, expansion of the Hindusthan Shipyard at Visakhapatnam, the Chittaranjan Locomotive works at Chittaranjan, the Integral Coach Factory at Perambur and the Government Electric Factory at Bangalore. Among light and medium industries scheduled for expansion are cables, instruments, silver refinery, tele-

TABLE IV—*Installed Capacity and Production Targets of Principal Engineering Industries in* 1956-61

Industry	1956—(Estimated)		1961—(Target)	
	Capacity	Production	Capacity	Production
1. Iron and steel (thousand tons):				
(*a*) Finished steel	1,300	1,300	4,500	4,300
(*b*) Pig iron for foundries	380	380	750	750
2. Structural fabrication (thousand tons)	242	180	500	500
3. Ferro-manganese (tons)	28,000	28,000	160,000	160,000
4. Aluminium (tons)	7,500	7,500	30,000	25,000
5. Locomotives (Nos.)	170	170	300	300
6. Automobiles (Nos.)	35,000	23,000	57,000	57,000
7. Heavy chemicals (tons):				
(*a*) Sulphuric acid	268,000	160,000	500,000	450,000
(*b*) Soda ash	90,000	80,000	280,000	250,000
(*c*) Caustic soda	46,000	35,000	133,000	120,000
8. Ship building (G.R.T.)	—	50,000	—	90,000
9. Cement (tons)	5,100,000	4,800,000	12,000,000	10,000,000
10. Refractories (tons)	343,800	260,000	1,000,000	800,000
11. Diesel engines (h.p.)	200,000	100,000	216,000	205.000
12. Electric motors (h.p.)	376,700	240,000	600,000	600,000
13. A.C.S.R. conductors (tons)	15,370	9,000	15,370	15,000
Transformers (kVA)	—	520,000	—	880,000

* Rs.1 = 1s. 6d. Rs.1000 = £75. Rs.1 crore = £750,000.

printers, and printing machinery. Similar large-scale expansion is also envisaged for private industry.

The demand for coal at the end of the second plan is expected to be about 60,000,000 tons, 23,000,000 tons more than the present demand. A target of 60,000,000 tons has therefore been set which includes the requirements of coking coal for the iron and steel industry. For minerals other than coal, production is to be trebled during the plan period. The exploration and development of oil resources is to be accelerated, for which an agreement has been signed with the Soviet Union which will provide the necessary technical assistance and personnel.

Irrigation and Power

During the first plan installed capacity increased by 1,100,000kW to 3,400,000kW, and *per capita* consumption rose from 14 to 25 units. It has been estimated that over the next ten years installed capacity will need to be expanded by 20 per cent annually ; this means that the target for 1966 should be about 15,000,000kW. In the second plan, the *per capita* consumption figure is expected to double from 25kWh to 50kWh, and the total installed capacity rise to about 7,000,000kW. Of the increase, hydro-power will account for about 70 per cent of the total capacity, the rest being contributed by thermal stations, mostly coal-fired. In all, forty-two new power generating stations will be taken up, twenty-three hydro and nineteen thermal. Rural electrification will be carried a step forward by providing power supply to small towns with populations between 5000 and 20,000.

Most of the new irrigation schemes in the second plan will be of medium and small size as against the big multi-purpose projects in the first plan. Out of 188 new irrigation projects, 136 will cost less than Rs.1 crore, 34 between Rs.1 crore and Rs.5 crores, 8 between Rs.5 crores and Rs.10 crores, 9 between Rs.10 crores and Rs.30 crores, and only one more than Rs.30 crores. There will be smaller irrigation works such as tanks and minor irrigation channels, but most of these will be undertaken by the Community Projects Administration with occasional help from the public works department. In India, these minor irrigation works play an important part in the economic life of the country : in 1950 they accounted for more than one half of the irrigated area of the country. All these projects will raise the figure for irrigated area from 7,000,000 to 12,000,000 acres.

Transport and Communications

Rs.1384 crores (out of the total of Rs.4800 crores) have been allotted to transport,* by far the largest allocation under the plan. Of this, Rs.900 crores have been provided for the railways, Rs.268 crores for roads, Rs.97 crores for shipping, ports and harbours, lighthouses and inland water transport, Rs.44 crores for civil air transport and Rs.75 crores for communications and broadcasting.

With a capital of about Rs.960 crores and a total mileage of 35,000 miles, Indian railways are the largest national undertaking, and will always be one of the principal foundations on which the Indian economy rests. Their principal task in the second plan is to meet the increasing demands for goods and passenger traffic. The volume of goods traffic is expected to increase by about 51 per cent from 120 million tons at the end of the first plan to 180 million tons by 1961. The plan will meet only about 80 per cent of this increase and perhaps even less if funds are not made available for the replacement of old stock: 850 miles of new lines will be constructed during the period, and there is provision for the doubling of 1600 miles and the conversion of 265 miles of metre gauge lines into broad gauge. About 1300 miles will be "dieselised" and another 800 miles electrified. It has been estimated that foreign exchange of the order of Rs.425 crores will be needed for the fulfilment of the railways' programme.

Table V gives the targets for railways, roads, shipping and ports.

The plan gives detailed programmes for scientific research, village and small industries, social services and agriculture. The general perspective of the planners is vaguely "socialistic" and the preamble makes it quite clear that although private enterprise will be welcome, the onus of developing the country must needs fall on the state which will call the tune. The achievement of a socialist pattern of society is accepted as the objective of economic policy and all major decisions regarding production, distribution, consumption and investment—in fact, the entire pattern of socio-economic relationships—are to be made by agencies "informed by social purpose." "For creating these conditions," the Planning Commission states, "the state has to take on heavy responsibilities as the principal agency for and acting on behalf of the community as a whole. The public sector has to expand rapidly and the private sector has to play its part within the framework of the comprehensive plan."

Table V—*Production and Targets for Railways, Roads, Shipping and Ports*

	1950-51	1955-56	1960-61	Percentage increase in 1960-61 over 1955-56
Railways :				
Passenger train-miles (millions)	95	108	124	15
Freight carried (million tons)	96	120	162	35
Roads :				
National Highways (thousand miles)	11·9	13	13·6	5
Surfaced roads (thousand miles)	97	102	111	9
Shipping :				
Coastal (million G.R.T.)	0·22	0·32	0·43	3·4
Overseas (million G.R.T.)	0·17	0·28	0·47	6·8
Ports:				
Handling capacity (million tons)	20	26	33·8	30

The plan has been criticised in some quarters as unduly ambitious and unrealistic. But it is clear that the Government is determined to implement it despite some very real difficulties, such as the paucity of technical and administrative personnel and the uncertainty of foreign assistance. Mr. Nehru who introduced the plan in the Parliament last May has said that "India's very existence is dependent on the success of the plan. If we fail, the whole political and economic pattern of Asia might undergo a change which we may not be able to control and influence." The plan came into force officially on April 1, 1956.

African Engineering News

BY OUR SOUTH AFRICAN CORRESPONDENT

Hail Resistance

The announcement that the new building for the Transvaal Provincial Administration in Pretoria is to be a reinforced concrete structure clad with aluminium, in place of the more conventional masonry, has been received with considerable interest in the building world, as this is the first time this material has been used in the inland areas of South Africa for a large building. Overseas, aluminium has been used for cladding buildings with considerable success, notable examples being the Alcoa aluminium skyscraper in Pittsburgh, and the Rockefeller Centre in New York, but it has still to be proved under our somewhat different climatic conditions. For the most part these are probably more favourable to longer life than the more extreme conditions of the United States, but in one respect they are likely to be more rigorous, namely, the occasional hailstorm in which individual stones may reach a diameter of up to 3in. This point is now being investigated by the S.A. National Building Research Institute, which is carrying out an investigation on the proposed aluminium cladding for the north and south faces of the blocks making up the building. The same equipment is being used for these investigations as has already been used by the Institute in roofing tests. Preliminary investigations have shown that aluminium sheeting of the thickness usually used for such cladding would certainly be damaged in a hailstorm as severe as that which struck Pretoria in November, 1949. They have shown, however, that if a light hardboard packing is provided, the aluminium should not suffer any damage from such a storm. Investigations are continuing to decide what combination of thickness of aluminium and thickness of backing will give the most economical and satisfactory results.

S.A.R. Cape Development

South African Railways is to spend many millions on maintenance and improvements in the Cape Midlands section. Working is continuing on the regrading of the Midlands line, which will cost £8,000,000 to complete. The Barkly Bridge, at present a steel structure, will be replaced by a reinforced concrete bridge costing £197,000. The present Great Brak River bridge will also be replaced by a reinforced concrete structure. The 300ft span rail bridge over the Swartkops River, 7 miles from Port Elizabeth, is now being completed at a cost of £190,000.

The present goods sheds at Port Elizabeth are to be removed from the harbour area to the North End at a cost of £12,268,000, and work is now in progress in the harbour on the building of extra berths at No. 3 quay at a cost of £1,361,000, on precooling chambers costing £480,000, and on the reconstruction of the Dom Pedro jetty at £108,150. Lengthening of the tanker berth has been completed at a cost of £108,150.

Provision of Dams in the Rhodesias

The latest report from the Director of Irrigation states that 1677 dams have been built in Southern Rhodesia in the past ten years and that the volume of water stored is nearly 90,000 million gallons. It will reach 124,000 million gallons when the Sebakwe Dam, now under construction, is finished.

Ndola, Northern Rhodesia is shortly going to require more water as its maximum daily demand is likely to reach 4,500,000 gallons by 1958, three years earlier than was anticipated in 1952. The council's consulting engineers have recommended applying for rights of abstraction amounting to an average of 4,250,000 gallons a day from the Iawa Dambo between July and December next year.

Que Que Water Scheme

Engineers and workmen are now putting the finishing touches to the giant water supply scheme in the Midlands which will provide all the needs for years to come of the Que Que Municipality, the Electricity Supply Commission's power station at Umniati, and the Riscom steel works.

A 115ft high wall—the highest in Central Africa—now spans the rugged gorge of the Sebakwe, 34 miles east of Que Que, and all that remains to be done is to cover the main buttresses with reinforced concrete slabs, a task which will be completed by August. During the next rainy season the dam will fill until it covers 3800 acres. The 6 miles long lake will hold 35,500,000 gallons of water.

The complete scheme—of which this dam is only a part—will be the largest water scheme yet undertaken in the Federation. The whole project has involved the planning of three river systems—the Umniati, Sebakwe and Que Que Rivers—the laying of an 18 mile concrete-lined canal and the building of the 1,250,000 gallon Dutchman's Pool dam, 40 miles below the Sebakwe dam on the same river.

New Gwelo Dam

A tender has been accepted for the construction of Gwelo's third dam—the Gwendora Dam—22 miles downstream on the Lundi River. The dam is now planned to be ready to store the 1957-58 rains, and will hold six times more water than the White Waters Dam completed in 1950 and eighteen times more than the town's oldest dam—the Ngamo—completed in 1934.

Gauge and Tool Exhibition.—The Gauge and Tool Makers' Association announces that, as member firms' requirements of space can no longer be accommodated in the New Horticultural Hall, Westminster, at which the previous Gauge and Tool Exhibitions have been held, the next exhibition will take place in the National Hall, Olympia, London, in May, 1958.

River Lech Hydro-Electric Scheme

WHEN fully developed the Bavarian section of the River Lech will have an installed capacity of nearly 385MW, with a mean annual generating power of 2005 million kWh. The principal scheme is that of Bayerische Wasserkraft-werke A.G. It comprises twenty-six power stations between Füssen near the Austrian border and Augsburg. With a total installed capacity of 270MW it will produce 1339 million kWh in the average year, of which 878 million kWh are to be generated in the summer, and 461 million kWh in the winter.

The key portion of the project is the Rosshaupten reservoir (Forggensee) which came into full operation last year. Covering an area of 15·7 square kilometres, this reservoir has a useful storage capacity of 135 million cubic metres. The power station is equipped with two Kaplan sets of 24MW each, laid out for a total flow of 150 cubic metres per second. The annual output is 168 million kWh, of which 48,300,000 kWh is winter power.

The history of hydro-electricity on the River Lech goes back to 1898, when Siemens and Halske acquired a concession for a turbine installation. A few power stations were constructed before 1940, among them those at Mangfall near Füssen, Lechbruck, Schongau and Gersthofen. A project for a reservoir near Rosshaupten, of 100 million cubic metres useful capacity, due to Kreuter and Maetz, was published by the Bavarian authorities in 1926.

In January 1940, the Bayerische Wasserkraft-werke A.G. (BAWAG) was formed with a capital of 15,000,000 R.M. (later increased to 30,000,000) put up in equal parts by Bavaria, the Rheinisch-Westfälische Elektrizitaetswerke A.G., and the Vereinigte Industrieunternehmungen A.G. Among the tasks of this undertaking was the development of hydro-electric power between Füssen and Augsburg.

The necessity for overall planning of the scheme had by then been realised. If the burden of solids carried by the water is retained behind a dam and at the same time the river below the dam is left with its old gradient, erosion of the river bed will take place rapidly. It was therefore decided to construct a total of twenty-six run of river stations between Füssen and Augsburg, making the tailwater of one station the headwater of the next. Construction of nine of these stations (stages 7-15) was begun, but was interrupted by the end of the war. It was not until 1947 that the work at these stations could be continued. Construction of the Rosshaupten reservoir began in November, 1950. By then, the plans made earlier had undergone substantial alterations, the site for the dam being changed from river kilometre 156·5 to its present site at kilometre 154, where soil conditions as well as general considerations are more favourable.

The next step will be the construction of intermediate reservoirs at Mering (stage 23), Dornau (stage 6) and Prem-Helmenstein (stage 2), which will allow the daily quantity of water to be regulated to the best advantage. Of these reservoirs, Prem-Helmenstein will have a useful capacity of 3,500,000 cubic metres, Dornau will have 6,000,000 cubic metres, and Mering, 3,000,000 cubic metres.

Calculations of the hydrology at Rosshaupten, based upon fifty years of observation, showed that on the average 26 per cent of the annual flow of 2200 million cubic metres occur in the winter and 74 per cent in the summer (1000 million cubic metres or 46 per cent in May-July). While the mean rate is 69·3 cumecs, the highest rate observed (in June, 1910) was 975 cumecs. The annual solid burden of the river, now completely retained between Füssen and Rosshaupten, is 140,000 cubic metres, while of 360,000 tons of suspended matter, only 75,000 tons pass downstream from Rosshaupten.

The layout of the scheme is illustrated in Figs. 1 and 2 and detailed in Tables I and II. The nine completed Lech River stations were laid out for 7·2MW and 120 cumecs each, delivering a total annual power of 280 million kWh to the grid at Meitingen.

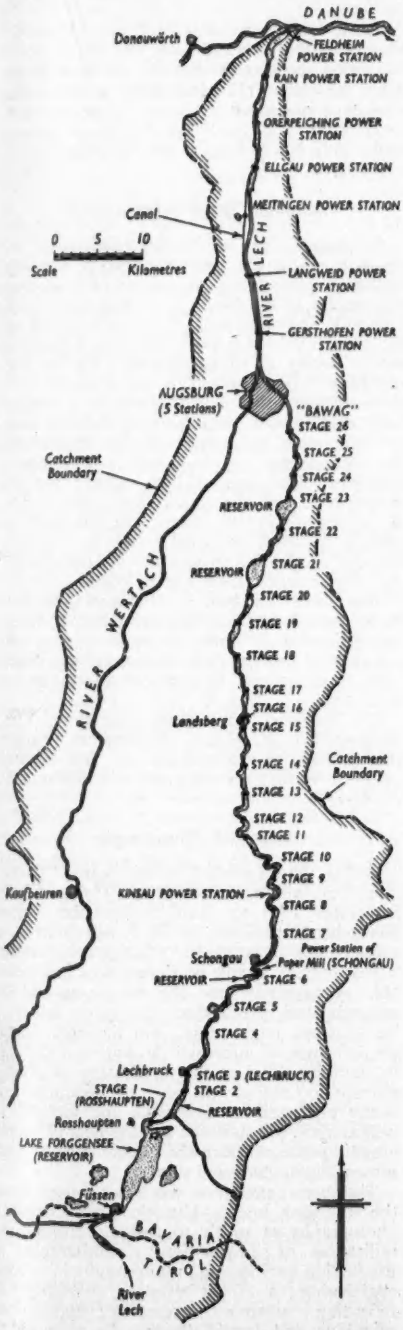


Fig. 1—River Lech hydro-electric development

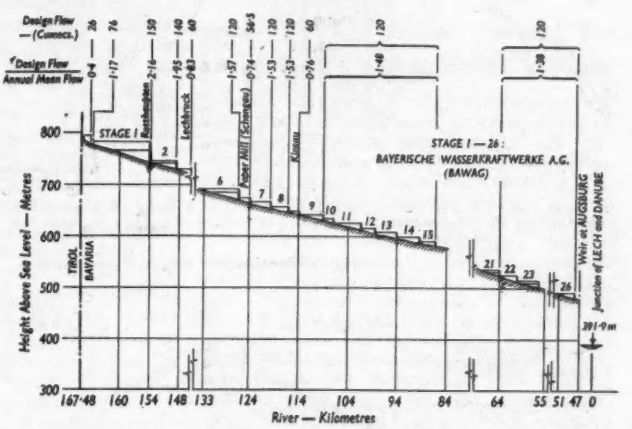


Fig. 2—River Lech power stations and reservoirs between Füssen and Augsburg

TABLE I—*River Lech Hydro-Electric Developments*

River km	Locality	Catchment area, km²	Mean annual flow, m³/sec.
0	Feldheim	4123(total)	119
38·4	Augsburg	2699	91
154	Rosshaupten	1582	69·3
165·4	Füssen	1425	65·0

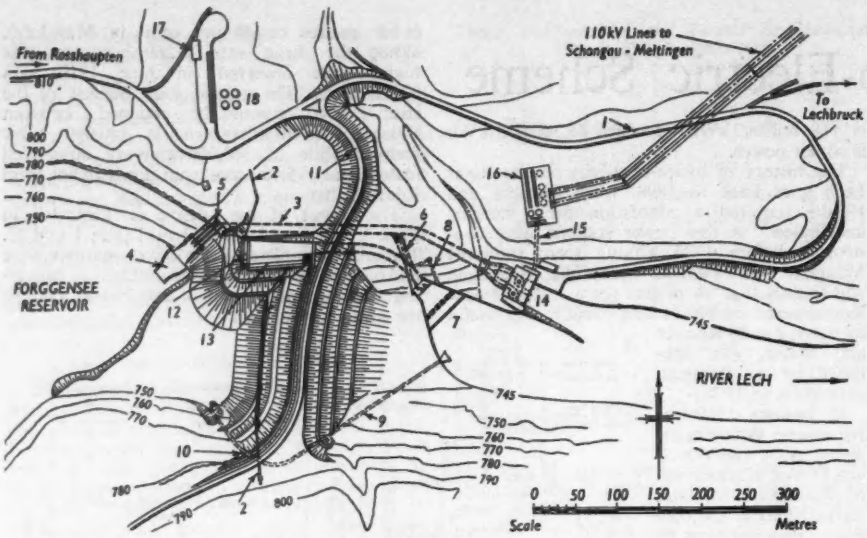
No. of power stations (completed or planned)	Situation	Installed capacity, MW	Annual output, millions kWh
7	Below Augsburg ...	64·3	402·1
5	at ,,	28·7	181
26	Rosshaupten to Augsburg, Bawag	276·2	1339 (winter 461)
2	,, other than Bawag	7·0	52·1
2	Füssen to border ...	6·4	30·4
42	Danube to border	382·6	2004·6

Rosshaupten power station is shown in Fig. 3. The dam is an earth dam with a clay core, and is shown in section in Fig. 4. It is 323m long at the crest, and has an overall height of 41m. Its width at the crest is 10m and the thickness at the base is 170m. The total volume is 634,000 cubic metres. All materials for the main structure of the dam were taken from those occurring naturally near the site, without the use of artificial means of obtaining water-tightness.

The clay core was compacted in layers 20 cm thick by means of Koppisch rollers, with girdle plates fixed to the roller circumference, using eight passes per layer. With clay of optimum moisture content, a permeability of 1×10^{-10} metres per second was obtained (corresponding to a rate of penetration of 3mm per year). The outer layers of the dam are composed of moraine and river gravel which after compacting to 17 per cent porosity, had permeabilities of the order of 1×10^{-4}m per second, or 36cm per hour. Compacting was carried out by means of an 8-ton, 3000 cycles per minute vibrator, with layers 1m thick. The water face slopes 1 : 1·75 and is pitched with stones, while the downstream face, sloping at 1 : 1·5, is covered with a layer of top soil over clay. An impermeable blanket

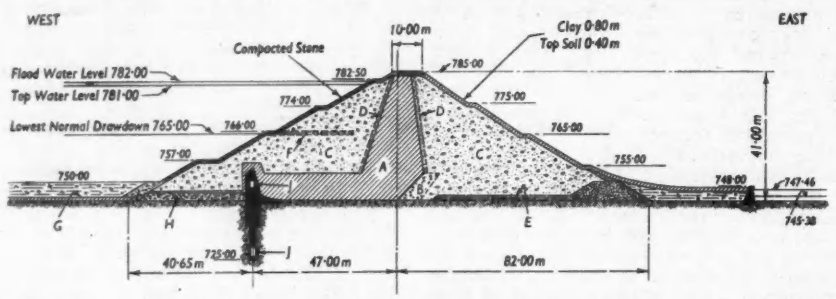
TABLE II—*Rosshaupten Reservoir and Power Station*

Reservoir :	
Capacity (total)	168 million cubic metres
,, (usable)	135 million cubic metres
,, (flood water)	16·2 million cubic metres
surface	15·7 square kilometres
Dam :	
Situation, river kilometre	154
Cut-off wall (concrete) height above river bed	10m
Cut-off wall depth below river bed	20m
Height	41m
Width at base	170m
Width at crown	10m
Length at crown	323m
Volume	635,000 cubic metres
Main tunnel (north)	8·35m diameter by 360m long prestressed by cement mortar injection.
Compensating tunnel (south) ...	2·2m diameter by 258 (340)m long, for 25 cumecs flow. Prestressed by Kunz DPA and Hamann processes.
Overspill (weir and 14 siphons) capacity	750 cumecs
Design flow	150 cumecs
2 Kaplan turbines, each	20-75 cumecs 200 r.p.m., 33,000 h.p.
Generators	2 of 24MW, 6·3kV each
Transformers	2 of 6·3/117kV, 31·5MVA each
Mean annual output	168 million kWh (winter 48·3 million kWh)



1. Access road. 2. Cut-off wall. 3. Main tunnel. 4. Intake. 5. Gates. 6. Scour culvert. 7. Stilling basin. 8. Access to scour culvert. 9. Compensation water tunnel. 10. Control valve shaft. 11. Road. 12. Spillweir. 13. Syphon spillway. 14. Power station. 15. Cable tunnel. 16. Substation. 17. Stores. 18. Cement silos.

Fig. 3—Rosshaupten dam and power station



A. Clay core. *B.* River gravel. *C.* Moraine. *D.* Screened river gravel. *E.* Sandstone. *F.* Drainage blanket. *G.* Existing clay layer. *H.* Stone overlaid with clay. *J.* Inspection tunnels.

Fig. 4—Cross section of Rosshaupten dam

was built at formation level on the upstream side of the core wall ; there are two inspection tunnels in the cut-off wall, and a mattress of stone, for drainage, on the downstream side.

Before the construction of the dam could be carried out, a diversion tunnel had to be built and the water diverted through it by means of an auxiliary dam. The required tunnel section was 54 square metres and it was decided to build a single tunnel of 8·35m diameter. The layout is shown in Fig. 3 from which it will be seen that the tunnel now serves as penstock for the power station, while part of it contains a 3·2m diameter pipe for scouring the reservoir. The stilling basin receives the flood overspill from a weir 21m long by 3m high and a siphon spillway, comprising fourteen siphons, which are built into two adjacent sides of a rectangular trough, have a total overflow capacity of 750 cumecs.

The main tunnel is designed for a pressure of 5·1 atmospheres gauge. For the lining of the straight sections the Kieser-Berger method was employed. This involved the placement against the rock (marl and sandstone) of an outer tunnel lining of 9·21m internal diameter and a minimum thickness of 40cm of non-reinforced concrete.

Within this tunnel was produced, by means of steel shuttering, an inner concrete cylinder 35cm thick which was cast in sections of 5m at a time. A space of 3cm was left between the two cylinders which was afterwards filled with cement mortar under a pressure of 8 atmospheres gauge. In this way the concrete pipes were prestressed. Good contact between the outer lining and the rock was ensured by numerous injections both before and after prestressing. The part between the branch and the stilling basin was constructed in reinforced concrete.

The tunnel is continued in the open by a concrete pipe of 8·35m internal diameter reducing to 7·50m which is surrounded by a steel pipe 28mm thick, the space between the two being filled with grout under pressure. A Y-piece of 7·50m internal diameter at one end and 2×4·5m at the other, and weighing 750 tons, distributes the water to the two Kaplan turbines.*

In addition to the main tunnel, there is a compensating conduit to the south of the dam. This is laid out for a flow of 25 cumecs and has a diameter of 2·2m and an underground length of 258m, with a total length of 340m. The tunnel has a wedge-shaped sluice gate. For the lining, two processes were used for the first time. Of these, the Kunz D.P.A. process, due to Dr-Ing. Jauch, consists in prestressing the lining with the help of longitudinally inserted flattened pipes which are hydraulically expanded. In the other process, due to Hamann, a comparatively thin lining is subjected to the full working pressure, and grouting is injected through the cracks which are formed.

The designed capacity of each turbine ranges from 20 cumecs (efficiency=80 per cent) to 75 cumecs (efficiency=90·5 per cent), for gross heads of 20m (minimum) and 37m (maximum). Each turbine runner has a diameter of 3·5m, and operates at 200 r.p.m. and 33,000 h.p. A 24MW, 6·3kV generator is driven by means of a shaft 60cm in diameter and 8m long. The electric power passes through a busbar tunnel to the substation which is equipped with two 6·3/117kV, 31·5MVA transformers with on-load tap-changing, as well as with the necessary switchgear.

Rhine Bridge, Mannheim-Ludwigshafen

On July 26th of last year, the Mannheim municipality decided to have a new bridge built over the Rhine between Mannheim and Ludwigshafen. A total of fifty-four designs were tendered by fifteen firms, and it has now been announced that the design submitted by Demag A.G., of Duisburg, has been accepted. The bridge is to have three spans of 91·3m each. The main structure will have four continuous box girders, a continuous steel plate forming both the top members of the box girders and the carriageway. A box construction was chosen on account of its great torsional stiffness, in consequence of which it is possible to achieve an advantageous load distribution and an economic design of the girders.

The cross-section is unsymmetrical. A carriageway 19m wide is followed on each side by a 2·5m wide cycle path, and cantilevered footpaths of 2·7m width upstream and 3·5m width downstream. The four main box girders are 2·5m wide, the inner ones, which are 2·5m deep, being 1·35m from the centre line, while the outer ones, which are 2·8m deep, are under the cycle tracks. In this way the unsupported parts of the carriageway have spans of 2·7m and 5·65m respectively ; a plate thickness of 12mm to 14mm is used. Cross girders are placed at 2·03m centres and longitudinal box girder stiffeners are used. Over most of its length the bridge will be 30·2m wide between railings, but will be gradually widened by a further 6m on the Ludwigshafen side. Two tramlines of 1m gauge will be placed symmetrically in respect to the bridge axis at 2·7m centres. The bitumen road surface will be 65mm thick at the crown, tapering to 50mm at the sides.

In the main a welded construction is to be employed, with riveted assembly of the prefabricated sections at the site, using steels of types St37 and St52 in weldable grades. The work is to be carried out in two stages so as not to interrupt traffic on the existing temporary bridge until one half of the new bridge is ready to take over.

* See THE ENGINEER, April 29, 1955, page 605.

Aluminium Brightening Process

A process for brightening aluminium by chemical means has been developed by the German Erftwerk works. It consists of immersing the articles in a solution of mainly ammonium bifluoride and nitric acid. The rate of attack on the metal is very high and brightening is achieved within twenty to thirty seconds. Careful prepolishing is not essential, a fact which, besides saving labour costs, makes the process invaluable when dealing with components which are difficult or impossible to polish. After brightening, the components are anodised in a sulphuric acid electrolyte, using a high voltage and low temperature, and the anodic film is then sealed in boiling water. By dyeing the film prior to sealing a variety of colours can be obtained. For the anodic film to remain fully transparent, the metal must be of the highest purity.

The process has been on trial during the past three years in the German car industry, where its application is stated to be increasing. Its use enables aluminium to replace chrome-plated steel, brass or zinc, in such components as car trimmings.

The London Aluminium Company, Ltd., Westwood Road, Witton, Birmingham, 6, states that it has been appointed the first licensed operator for the Erftwerk process in this country.

Industrial Photography

Within the framework of this year's " Photokina " exhibition, to be held in Cologne from September 29th to October 7th, the Verein Deutscher Ingenieure (V.D.I.) will present a special show, entitled " Photography Helps Technology." It will be shown how indispensable photography has become as an aid to research and production in many fields of industry and engineering. On the other hand, the influence of industrial development on that of photography and the application of photographic techniques will also be demonstrated. Many photographs, apparatus and models, as well as films, will show the development of photographic processes from their beginnings to their present highly perfected state.

The special exhibition will be organised along the following lines :—Historical development ; photography as an aid to design ; sorting and utilisation of information ; photography in production engineering ; photography in process engineering ; as an aid in testing, metrology and recording ; as an aid in research ; applications of colour, and, lastly, photography as an aid to instruction and publicity.

The American Scene

BY OUR AMERICAN EDITOR

TROUBLE FOR TOLL ROADS?

PENNSYLVANIA started something in the mid-thirties when it considered the feasibility of building a toll highway that eventually became the Turnpike. Twenty years later the Pennsylvania Turnpike is still pushing in new directions across the state, but the last link to be put in place between east and west went into operation in May with the opening of the Delaware River Bridge. Thus, the toll roads of New Jersey, Pennsylvania and Ohio are joined and the motorist so inclined can drive from New York City to the Indiana border non-stop except for pauses to settle his accounts at state lines and turn-offs to eat, drink, sleep and fill up the petrol tank. The depression-born pioneering in Pennsylvania was contagious. New Jersey, New York, Ohio followed the leader, and now Indiana will soon deliver the cross-country driver to the edge of Chicago. Other states have built or will build and, until recently, the turnpike financed by toll-secured bonds had smooth going both in the financial and in the engineering worlds. In reviewing the history of American toll roads one can distinguish between three phases. The first phase was the development of the administrative concept of the "authority"—an autonomous subdivision of government that would function on a straight business basis independent of political considerations. The Pennsylvania Turnpike Commission was one of the first of these "authorities" to become widely known, and most of the toll turnpike and other like agencies set up thereafter by other states were fashioned after the pattern developed by Pennsylvania before World War II. The second phase of turnpike administration was that of the "boom." The high point was the earnings record marked up by the Pennsylvania Turnpike and its younger neighbour, the New Jersey Turnpike, in the early post-war years. But now the toll turnpikes are getting deeper into a third phase—that of disillusionment. Road use statistics have gone off in two directions not anticipated by the engineers. Short rather than long trips have become the earnings mainstays of the toll roads, and trucks are tending to rely more on free roads and less on toll turnpikes. These developments are raising serious questions as to the ability of certain major toll facilities to continue to meet their obligations to the bondholders on the basis of the present toll systems. One of these turnpike systems is that of West Virginia.

The volume of traffic forecast for the West Virginia Turnpike by its consulting engineers has failed to materialise; as a consequence, the revenues have fallen short of expectations and the securities involved have declined sharply in price. The basic facts of the story are quickly set forth. A few years ago, when the toll road boom was starting to roll, the West Virginia legislature, like others, set up a Turnpike Commission. After extensive surveys, the authorities decided that a highway which cut its way from Charleston, the state capital, southward through the mountains 90 miles to Princeton, would be feasible, both technically and economically. In April of 1952 the West Virginia Turnpike Commission sold 96,000,000 dollars worth of bonds, payable as to principal and interest solely out of revenues; some eighteen months later, it raised another 37,000,000 dollars for the scheme through a second bond offering. The road finally was completed in November, 1954. In some respects it was and is a major achievement. One underwriter, indeed, called the project with its fine surfacing, half-mile-long tunnel and seventy-six bridges, a marvel of engineering. Financially speaking, however, to date at least, it has evoked scanter enthusiasm. In fact, revenues and earnings have lagged alarmingly, and a recent increase in tolls has proved no remedy. Hence, while the turnpike has enough in the till to meet its obligations, at least for the time being, the American bond market has registered deep misgivings over its ultimate solvency.

For this distressing state of affairs there are, it seems, several explanations. One surely lies in the unusual physical features—some might say drawbacks—of the turnpike. For example, unlike its counterparts in other states, West Virginia's toll road throughout most of its length boasts only two lanes, instead of the customary four. Considering the rugged terrain traversed, this construction is understandable enough; however, to the lorry driver or motorist it is scarcely apt to be a selling point. The same might be said, for that matter, of the 90-mile route itself, which has moved one observer to label it the "turnpike to nowhere." While this tag, of course, is an exaggeration, it is true that the West Virginia Turnpike fails to connect major population centres, nor, at either end, does it link up with other "super-highways." But what now appears as the fatal mistake was made in the inflated estimates of the traffic which might use the new facilities. In retrospect, the errors seem obvious. Thus, the West Virginia Turnpike, though much shorter than the one in Pennsylvania and less strategically situated, was expected to draw more revenue from commercial vehicles. Such estimates, to date, have proven far too high. Thus, for 1955 it was forecast that more than 2600 commercial vehicles per day would use the road, contributing in the process more than one-third of its total revenues. Actually, fewer than 1000 trucks daily have chosen to come down the 'pike. In defence of their projections, the consulting engineers may point to other toll roads, where traffic consistently has outrun expectations. Yet the fact remains that in regard to West Virginia, at any rate, the slide rule obviously has not proved infallible. And the easy optimism of investors, based on the previous record of success in this field, is threatening to backfire. It should be mentioned that this tale of a turnpike could yet have a happy ending. The West Virginia Commission evidently is making every effort to build up traffic, and there is some possibility that the state will lend a helping hand financially to forestall default. In addition, it is hoped, several neighbouring states sooner or later will launch road-building programmes of their own, which one day might make the West Virginia 'pike a vital link in a north-south network of "super-highways." But however the last chapter may be written, the moral of the story seems plain. Future plans for toll roads in America are now being critically re-examined, and many schemes have, in fact, been cancelled or postponed. Furthermore, it has become a generally accepted concept that the days of the long-distance toll road are over. Instead, the more feasible ventures will be relatively short stretches of toll highways linking large urban centres, with free roads constructed with federal and state funds bridging the gaps to create an up-to-date system of trunk roads throughout the United States.

Issue of Construction Permits for Large-Scale Nuclear Power Stations

THE U.S. Atomic Energy Commission has announced that permits for the construction of power reactors—the first permits for the private construction of large-scale nuclear power plants in America—have been issued to the Consolidated Edison Company of New York and the Commonwealth Edison Company of Chicago.

Each of the construction permits allocates special nuclear material to be made available over a forty-year period for use as reactor fuel. The amounts calculated for the period are: for Consolidated, 5699 kg of U-235; for Commonwealth, 8323 kg of U-235.

Consolidated Edison plans a power station, using nuclear and conventional fuels in combination to generate 236MW of electricity. The station will be built on a 350-acre site lying along the Hudson River near the village of Buchanan in Upper Westchester County, about 24 miles north of New York City. The Commonwealth Edison station, with a net generating capacity of 180MW of electricity, will be built on a 950-acre site in Grundy County, Illinois, about 50 miles south-west of Chicago.

Consolidated Edison is authorised to build a pressurised water converter reactor designed to furnish energy equivalent to about 140MW of electricity. By using an oil-fired superheater to raise the steam temperature to about 1000 deg. Fah., the company proposes to produce an additional 96MW of electricity to be fed into its transmission system. The reactor will be fuelled by highly enriched uranium and will use thorium as a "fertile" material. This involved placing thorium metal in the core of the reactor for conversion into U-233, a fissionable material useful as reactor fuel. Consolidated Edison expects that its reactor will consume 155 kg of U-235 each year during "steady state" operation, which should be achieved after about two years. In turn, 140 kg of U-233 will be produced, of which 62 kg will be consumed in the operation of the reactor.

The permit issued to Commonwealth Edison authorises the construction of a dual cycle boiling water reactor. The reactor is to be fuelled with uranium slightly enriched in the isotope U-235 and is designed to produce approximately 180MW of electricity. Commonwealth Edison estimates that the reactor will consume 225 kg of U-235 each year during "steady state" operation, which should be achieved in about four years after operations commence. Before issuing the construction permits the Commission determined that the two companies had submitted sufficient information to give reasonable assurance against risk to the health and safety of the public.

The "hazards summary report," on which the Commission will base its final determination as to the health and safety aspects of the two power reactors, is a detailed report, to be prepared by the applicant as he works out his design, in which he tries to anticipate all possible ways in which radio-active products might accidentally be released. The Commission may issue a construction permit if satisfied that it has enough information to give reasonable assurance that a certain reactor can be built and operated at the proposed site without endangering safety, and that additional information will be supplied later. This procedure was followed in granting the construction permits to both Consolidated Edison and Commonwealth Edison.

Industrial Nuclear Facilities Works in Virginia

No. II—(*Concluded from page 141, July 27th*)

The nuclear facilities works of the Babcock and Wilcox Company at Lynchburg, Virginia, went into operation in May. The installation is believed to be the first major facility in the United States erected entirely at private expense to manufacture and test nuclear fuel elements and related reactor components for peaceful use. The works comprise a fuel element fabrication shop with metal casting, rolling, welding and machining equipment and a reactor critical experiment facility to be used for the study and testing of reactor core components.

Reactor Fuel Elements

THE initial operations at Lynchburg are devoted to the production of flat-plate fuel elements and core assemblies for nuclear reactors. A reactor fuel element is made up primarily of fissionable material enclosed in a protective cladding. When a number of fuel elements are assembled into a reactor core in a certain manner, a critical mass is obtained. When a chain reaction begins, atoms of fissionable material are partially converted from mass to energy in the form of heat. A fuel element assembly may also contain a fertile material, such as uranium 238, or thorium, which is converted to fissionable material at the same time as the chain reaction is taking place. For example, each fuel element for the nuclear steam generator which the firm has contracted to design, manufacture and construct for the Consolidated Edison Company comprises a sandwich of plates that contain, alternately, thorium and uranium 235. During the chain reaction a new fuel known as uranium 233 is made in the fertile thorium plates.

Currently, the company is producing at its Lynchburg works a year's supply of fuel elements (Fig. 7), to be used in the Materials Testing Reactor (MTR) at the National Reactor Testing Station at Arco, Idaho. Under the terms of the contract with the Phillips Petroleum Company, which is operating the MTR for the U.S. Atomic Energy Commission, Babcock and Wilcox will produce 325 of these fuel elements for delivery beginning this month. The plates of the MTR elements are an alloy of aluminium and uranium 235.

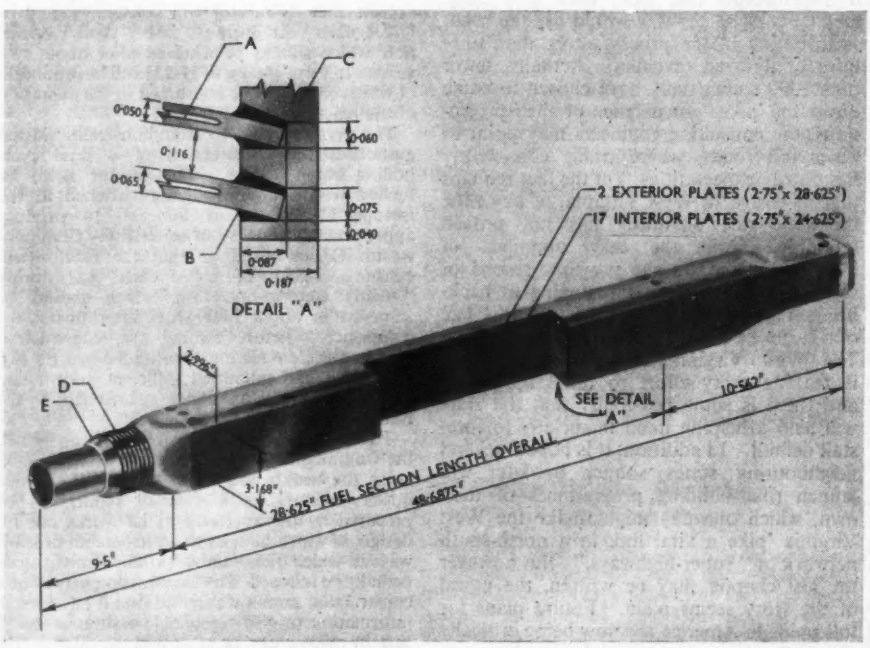
Two major designs of fuel elements are in use in America to-day. One is the rod, pin or slug type, which may vary from 0·30in to 2in in diameter and from 4in to 10in in length. An example of this form is the "natural uranium slug," measuring about 1in by 8in, employed for producing plutonium. A second design is the strip or plate form. It may vary from 0·01in to 0·35in thickness, from 2in to 5in in width, and may be 2ft to 15ft long. The MTR plate fuel element is approximately 0·05in thick, 3in wide and 30in long.

All fuel elements being produced at Lynchburg are clad with protective coating, usually of aluminium, zirconium or stainless steel. This cladding prevents local "hot spots," corrosion, metal distortion due to irradiation instability, and the resulting escape of radioactive fission gases, and also confines the solid fission products to the "meat" of the fuel. Because a defective fuel element could contaminate an entire reactor core and force a costly shut-down, the manufacturing operations at the new works are based on extremely fine tolerances and intensive inspection. The high cost, strategic value and potency of fuel element components also demands an accountability system which constantly shows the disposition and situation of materials down to 1/100th of a gramme. A sequence of operations drawn up for the production of the Consolidated Edison reactor fuel element assemblies illustrates the complexities of processing nuclear materials.

Zirconium and enriched uranium metal for fuel plates will be alloyed in the vacuum arc melting furnace. The 100 lb ingot cast will be re-melted to improve homogeneity. At this stage the ingot will be worth approximately 40,000 dollars. The ingot will then be conditioned on a 10in lathe to remove imperfect material and sheathed in steel. Next it will be preheated to about 1450 deg. Fah. for hot forging on the "Impactor" into a billet for rolling. The billet will be reheated and hot rolled on the two-high/four-high combination rolling mills to the approximate fuel element core thickness. At this point the steel sheath will be removed and the plate will be cleaned by vapour blasting and acid pickling and cold rolled to punching thickness. Core size pieces will be punched from the plate on a 160-ton press and assembled in a "picture frame" with zirconium alloy cladding. These assemblies will be sheathed in steel once more, heated in an electric furnace to about 1450 deg. Fah. and hot rolled to the approximate finished fuel plate thickness. The removal of the protective sheath takes place subsequently. The element will then be cleaned by vapour blasting and acid pickling, and cold rolled to final thickness. Each plate will be examined in the laboratory fluoroscope to indicate the exact position of the "meat," and then machined to final width and length.

Thorium for the fertile plates will be received in ingot form. The ingots will be preheated in the salt bath furnace to 1400 deg. Fah. and hot forged into billets for rolling. Reheating in the salt bath furnace to 1400 deg. Fah. will follow, after which the billets will be hot rolled to the approximate "meat" thickness. After cleaning by pickling the strip will be cold rolled, punched to the proper thickness and width, and assembled with zirconium alloy cladding. These assemblies will be sheathed in steel, heated in the electric furnace to about 1400 deg. Fah., and given moderate hot rolling passes. The assembly next will be given a diffusion anneal in an electric furnace, followed by reheating and completion of hot rolling to the approximate finished plate thickness. The steel sheath will then be removed, the plate cleaned by pickling, and cold rolled to the final thickness. This plate also will be checked on the fluoroscope to indicate the "meat" before being machined to the final width and length.

Before assembly into a "bundle" the plates will be acid cleaned and rinsed in water. In bundling, thirty thorium plates and thirty-eight uranium 235 plates will be positioned in a jig and fusion welded. The welded assembly will be moved to an electric furnace and given a diffusion anneal. This operation will stress relieve as well as anneal. The assembly will then be moved to the large milling machine, where it will be machined to final dimensions. After machining, the assembly will be placed on a large granite surface plate for inspection and the recording of dimensions. End nozzles will be attached to the assembly by stainless steel rivets. The assembly then will be moved to the 20in centre lathe for final end nozzle machining, after which it will be given an acid cleaning and a water rinse. After final inspection the bundle will be identified on the outside by the engraving of a code number and then readied for shipment.



A—13 per cent U 235—83 per cent aluminium alloy (0·020in).
B—12 per cent silicon aluminium brazing alloy.
C—S S aluminium.
D—Stainless steel.
E—3 S 1/2 H aluminium.

Fig. 7—Fuel element assembly for Materials Testing Reactor of the U.S. Atomic Energy Commission

Accountability Procedures

Fissionable materials, such as uranium 235, are turned over to the company on a loan basis by the U.S. Atomic Energy Commission. Some others, including natural uranium, thorium and zirconium, can now be purchased from private industry in America. In the case of fissionable and source materials the works management must have available at all times records of the disposition and location of all such materials in its possession. A source materials is one which contains or can be transformed to fissionable material. The known source materials are natural uranium and thorium.

The accountability programme now in operation at Lynchburg is based on a specialised personnel organisation, elaborate instrumentation, and extensive recovery and storage facilities. A central accountability station has been established in the works. Records showing the movement, location, properties and disposition of all nuclear materials are directed to this station for the compilation of master records and the issuing of monthly accountability reports. A number of accountability sub-

stations are situated at strategic points throughout the works. Materials flow through these substations at each step of handling and fabrication, and careful records are kept of each transaction. For the storage of fissionable materials, vaults have been built with walls of reinforced concrete about 1ft thick to withstand shocks of every conceivable type. When a container of fissionable material arrives at the works, the material is removed, identified, tagged and weighed. The material is stored on shelves, or in specially designed "bird-cages," so that the density is uniformly several times less than that required for a critical mass.

The storage shelves and compartments are designed to accommodate specified materials. For example, 4in by 4in sections of steel pipe are welded to shelves to provide fixed positions for materials in powdered or pellet form. Cadmium and boron liners and barriers can be inserted between the compartments to keep nuclear activity at a safe level. The personnel movement in and out of the vaults is carefully controlled and logged. Heavy steel doors with combination lock movements have been provided. Equipment within the vault includes counting instruments, delicate balances, and vacuum cleaning devices. Minute particles of fissionable materials can be recovered from the vault floors, which are coated with several layers of hard-finish paint to keep dust at a minimum and to aid in finding grains of fissionable material. Special carts have been designed to transport fissionable and source material about the works. The carts are colour coded to permit a "batch system" of material control, which means that components and scrap move as a unit wherever they go. Bright orange colour carts are used for the fissionable uranium 235; green for natural uranium; yellow for depleted uranium, and blue for thorium.

It has been said that wherever nuclear materials are handled at this installation, the atmosphere is literally being scrubbed to remove tiny particles of nuclear as well as other materials. The ventilating systems in the manufacturing area change the air twelve times an hour. The entire manufacturing area is maintained at an atmosphere pressure that is slightly lower than that of the laboratory and office sections. The purpose here is to direct the air flow through various doors and openings into the manufacturing area. Equipment which gives off higher than average amounts of airborne substances has been fitted with flexible ducts which provide ten changes of air hourly. The exhaust units for these ducts contain "absolute" filters which remove at least 99·5 per cent of the solid material in circulation. The filters are monitored regularly, and any fissionable material found is removed.

A special recovery area (Fig. 8) of 700 square feet has been built into the floor of the fabrication plant and is surfaced with acid-resistant brick. The recovery area is enclosed by a brick kerb and slopes toward a stainless steel sump. Liquid wastes from units such as acid pickle, rinse and hold tanks, an evaporator and a filter press are channelled to a 500-gallon stainless steel sump tank in an acid brick well. The wastes collected in the tank are sampled and analysed for possible salvage of fissionable material prior to their disposal. A retention area for liquid wastes, called a tank farm, has been built about 1000ft north of the fabrication building. The tank farm is housed in a separate structure and has a storage capacity of 4000 gallons. Its three steel tanks are interconnected to permit successive or individual filling. Each tank is equipped with sampling, recirculating and liquid measurement facilities. A discharge line connects the tank farm with the sewage disposal lines. In addition, the liquid wastes from employees' showers are discharged into the James River after dilution and treatment to reduce to safe limits any radioactivity they may contain. The limits are those prescribed by the U.S. Public Health Service with the advice of the U.S. Atomic Energy Commission and the National Bureau of Standards.

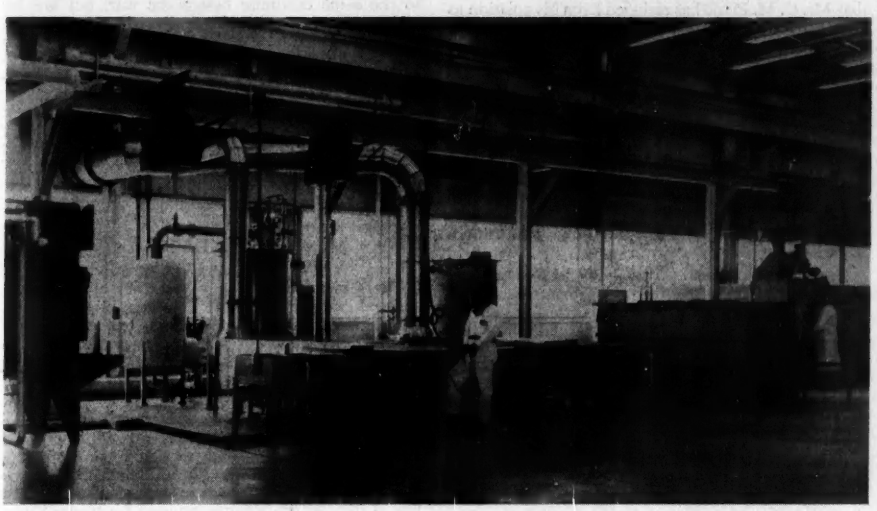


Fig. 8—Recovery area of fuel element fabrication shop with drying oven, pickling and rinsing tanks, degreasing unit and vapour blasting unit

All employees who handle unclad nuclear materials in the works are required to bathe in the works shower room and change clothes on leaving the work area. All clothing, dusting and wiping rags, as well as other fabrics which may have come in contact with these materials are checked with radiation monitoring instruments. If such materials show radioactivity when monitored, they are washed in a special laundry on the site. The liquid wastes from this laundry flow to the tank farm. Should subsequent laboratory analyses of samples, whether liquid or solid, reveal the presence of recoverable fissionable materials, they will be sent to the U.S. Atomic Energy Commission at Arco, Idaho, for reprocessing. Solids collected as chips and dust from filter media are stored under oil in drums for shipment. Other materials to be sent to the A.E.C. include contaminated clothing, rags and building material which cannot be cleaned satisfactorily for re-use. At present, and in the near future, all such material will be sent directly to the A.E.C. However, at a later date, a special incinerator will be constructed on the site and only the ashes will be shipped to the A.E.C. Radioactive materials from pickling, rinsing and degreasing solutions are concentrated in an evaporator and are then shipped in polyethylene-lined containers to the A.E.C.

Critical Experiment Facility

As an important part of its nuclear facilities works at Lynchburg, the Babcock and Wilcox Company will soon have in operation a critical experiment facility, the first to be licensed by the U.S. Atomic Energy Commission. The purpose of the facility will be to determine the physical and engineering characteristics of a nuclear reactor by operation of a scaled-down core at very low power. Critical experiments have these advantages over testing a full-size core at higher power: (1) minimum accumulation of radioactive isotopes and fission products is involved; hence there is very little hazard to the surrounding area; (2) the "mock-up" can be built much cheaper than an actual core; (3) there is no need for expensive equipment for the dissipation of large quantities of heat. The precise conditions under which a chain reaction can be achieved are called "critical conditions." At the present time, inadequacies in physical data, as well as in theoretical methods, prevent the reactor designer from specifying exactly the critical conditions and operating characteristics of new reactors. Thus a critical experiment must be carried out to check and modify the physicists' calculations.

The first scheduled experiment in the facility will provide information for the final design of the nuclear steam generator which the firm has contracted to build for the Consolidated Edison Company, of New York, and which is to be of the pressurised-water thorium converter design. The system consists of a uranium and thorium-fuelled reactor through which demineralised light water is pumped at high pressure and rate of flow. In the Consolidated Edison reactor water serves as coolant, moderator and reflector. The purpose of the water reflector is to return neutrons to the core, while the water moderator serves to slow the neutrons to useful velocities. The coolant transfers heat from the reactor to the steam generators. After leaving the reactor, the coolant water flows through connecting piping to the steam generators containing a great number of U-shaped stainless steel tubes. The steam generated in the water surrounding these tubes flows by means of risers to a steam drum, where it is dried by conventional steam generators. A turbo-generator then converts the steam to electrical energy. The primary water is pumped from the steam generators back to the reactor.

From the calculations of physicists and engineers the individual fuel elements for the Consolidated Edison reactor tests will be made to one-quarter scale. This quarter-size element was chosen to permit easier construction and handling in loading and unloading the core. However, these test elements will contain, in total, approximately the same quantity of uranium 235 which will be used in the full-size Consolidated Edison reactor. The scaled-down elements will contain "converter" plates. In these plates thorium will serve as a "fertile" material, in which new nuclear fuel is created as fissions take place in the reactor. It is hoped that the information to be derived from these tests with the small-scale assembly will help to determine (1) the adequacy of the theoretical methods used in reactor analyses; (2) the power distribution in the core assembly; (3) the composition, size, number, value and arrangement of the safety and control rods. The normal operation of the assembled core will be at a heat release power level of a fraction of a watt. For short periods of thirty minutes or less a power level between 10W and 100W may be maintained.

The fuel material consisting of uranium 235, which will be used in the first test assembly, will be dispersed in plastic tape and sandwiched between the thorium "converter" plates. In addition to providing a dispersal medium for uranium oxide, the plastic tape will be a self-contained safety device. In the event of safety rod failure the rising power in the core will cause gas bubbles to form in the plastic, and this will force an automatic shut-down of the nuclear reaction. Despite the low energy levels at which the experiments will be performed, numerous safety devices are fitted to ensure absolute protection to individuals inside and outside the critical experiment building. There are, for example, four independent and automatic safety rod systems, which can "scram" the critical assembly in an extremely short time interval. Any power interruption will cause the rod system to be activated through any of five separate electronic channels. In addition, the water moderator will be dumped and drained automatically if reactivity within the core should approach an unsafe limit. Without the water moderator the reactor will not be "critical."

Personal and Business

Appointments

MR. G. A. DUMMETT, M.A., A.M.I.Chem.E., has been elected to the board of directors of the A.P.V. Company, Ltd.

MR. E. P. HOLMES, B.Sc., has been appointed executive engineer of the Borg-Warner Automotive Transmission Factory, Letchworth.

MR. G. E. MAYNE has been appointed vice-president, Prairie Region, Canadian Pacific Railway, Winnipeg, in succession to Mr. C. E. Lister, who retired at the end of July.

THE INSTITUTE OF WELDING announces that Sir Charles Lillicrap, K.C.B., M.B.E., D.Sc. (Eng.), has been elected president for 1956/57, and Mr. J. Strong, M.A., has been elected vice-president.

CANADIAN PACIFIC STEAMSHIPS, Ltd., states that Mr. J. R. Y. Johnston, the general superintendent for construction, has been appointed managing director, in succession to Mr. A. C. Macdonald, who has resigned.

NATIONAL GAS AND OIL ENGINE COMPANY, Ltd., Ashton-under-Lyne, announces that Mr. B. R. Cant, general works manager, has been appointed works director and Mr. J. Smith, chief engineer, technical director of the company.

MR. L. REDSHAW, M.Eng., M.I.N.A., M.Inst.W., has been appointed an additional member of the board of directors of Vickers-Armstrongs (Shipbuilders), Ltd. He will retain his present office of shipbuilding general manager of the company.

MR. J. JACK and Mr. J. H. Patchett have been appointed directors of Dorman, Long and Co., Ltd., and Mr. W. S. Fletcher, managing director of Tees Side Bridge and Engineering Works, Ltd., has been appointed a special director of the company.

BILSTON FOUNDRIES, Ltd., announces that Mr. H. C. Sargent has resigned as chairman of the company owing to ill health, but will retain his seat on the board as consultant director. Mr. T. I. Hobart, managing director, has been appointed chairman of the board.

THE INTERNATIONAL SHIPPING FEDERATION announces the appointment of the following office-bearers for the ensuing year: Sir Donald Anderson (Great Britain) as president, and Mr. W. N. H. Van der Vorm (Netherlands), Captain Odd. I. Loennechen, O.B.E. (Norway), and Mr. Maitland S. Pennington (U.S.A.) as vice-presidents.

ENGLISH STEEL CORPORATION, Ltd., announces the appointment of Mr. J. T. W. Dewar as an additional director of the company, with effect from September 1st. Mr. Dewar is deputy managing director of Firth-Vickers Stainless Steels, Ltd., and managing director of Shepcote Lane Rolling Mills, Ltd., and he retains both of these appointments.

MR. DOUGLAS L. STANDLEY has terminated his appointment as personal assistant to the chairman and group managing director of the Teddington Group of Companies on taking up an appointment with Masson Scott and Co., Ltd., of Riverside Road, Summerstown, S.W.17, as assistant to the deputy chairman and managing director.

GEORGE ELLISON, Ltd., Perry Barr, Birmingham, 22b, has drawn our attention to the fact that it is particularly in connection with the firm's hydraulic valve and not its electrical business that Mr. L. A. Yardley was appointed engineer responsible for the sales and consultative service in the North, as announced in this column of July 20th last.

THE BOARD OF TRADE announces the appointment of Mr. Bernard A. Hopewell and Mr. Walter T. Wren to be members of the Council of Industrial Design. Mr. W. J. Worboys, B.Sc., Ph.D., has been re-appointed chairman, and the Lady Sempill, A.R.C.A., Mrs. Alison Settle, Sir Colin Anderson and Mr. J. Cleveland Belle members on the termination of their existing appointments.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces the appointment of Mr. R. E. Prickett as branch manager in London in succession to Mr. R. L. Packer, who has been appointed regional manager, North West Region, on the retirement of Mr. J. L. Morley. Mr. G. F. Huddleston has been appointed branch manager at the firm's Brighton office in succession to Mr. Prickett.

Business Announcements

THE BELMOS COMPANY, Ltd., announces that the firm's London office has been moved to a new suite of rooms on the second floor of Columbia House, Aldwych. The telephone number is now Chancery 5953/4.

THE SKEFKO BALL BEARING COMPANY, Ltd., of Luton, has opened a new branch office at Noverre House, Theatre Street, Norwich (telephone number, Norwich 28949).

GEO. SALTER AND CO., Ltd., announces that manufacturing sections of its subsidiary, the Crown Spring Company, Ltd., are being transferred from premises in Littleton Street, West Bromwich, to the new Salter factory at Spring Road, Smethwick.

SANDERS AND FORSTER, Ltd., Thames Works, Hertford Road, Barking, Essex, announces that Mr. D. R. J. Cook has been appointed export manager. Mr. Cook will operate from the company's office at 3, Buckingham Palace Gardens, Westminster, S.W.1.

SKINNERS (REDBRIDGE), Ltd., has moved into new and more spacious premises in the Millbrook Trading Estate, Southampton. Coinciding with this move, the name of the firm has been changed to Skinners (Southampton), Ltd. The new telephone number is 71167/8.

NORRIS, HENTY AND GARDNERS, Ltd., announces that Mr. C. M. Plane has resigned from his position as sales manager and director of the company. Mr. D. G. Houghton, manager of the firm's London office and service depot, is to be transferred to the head office to take over duties of sales manager, and he will be succeeded in London by Mr. Geoffrey Sutcliffe.

THE DAVID BROWN COMPANIES state that a new assembly and distribution centre for David Brown tractors and implements has been established at Adelaide, South Australia. The new plant will function as a branch of David Brown (Australasia) Pty., Ltd., of Lidcombe, New South Wales, which has handled direct wholesale trading in Australia since 1955.

HERCULES POWDER COMPANY, Ltd., announces that by mutual agreement with Algemene Kunstzijde Unie N.V. of Arnhem, Holland, arrangements for the distribution of "Akulon" polyamide moulding granules and rod material have been terminated. Distribution of this material is now in the hands of B.X. Plastics, Ltd., Chingford, London, E.4 (telephone number, Larkswood 5511).

THE board of directors of the Birmingham Small Arms Company, Ltd., announces that Lazard Brothers and Co., Ltd., and Messrs. Deloitte, Plender, Griffiths and Co., chartered accountants, have been appointed independent advisers to make an examination of, and to report on, the structure and organisation of the group. This follows the unanimous decision of the board on June 8th last to obtain advice as to the future organisation of the whole B.S.A. Group of Companies.

RANSOMES, SIMS AND JEFFERIES, Ltd., announces that its sales department, under the sales director, Mr. W. D. Akester, has been reorganised, and Mr. J. S. Canning has been appointed general sales manager. Mr. F. G. Newman becomes the agricultural home sales manager, and Mr. W. F. Cairnes the agricultural export sales manager. Mr. R. B. Ransome has been appointed industrial sales manager, in charge of fork lift and battery trucks and machine tools, with Mr. C. P. Seager to assist him. Mr. E. J. Bradley is now the firm's lawn mower sales manager, assisted on the home sales side by Mr. D. P. Gilbert, and on the export side by Mr. B. C. Jennings.

Contracts

F. W. BRACKETT AND CO., Ltd., has received a contract from the Central Electricity Authority for the supply of three double-entry drum type automatic water screens for the Northfleet power station. The installation will be for continuous operation and the screens will each be 44ft diameter by 8ft wide, with a capacity for handling about 4,000,000 gallons of water per hour.

BOVING AND CO., Ltd., has received from the State Hydro-Electric Department of New Zealand an order for three Kaplan turbines for the new Waipapa station on the Waikato River. The turbines will be designed for an output of 24,000 b.h.p. each, with a head of 53ft and a speed of 125 r.p.m. This company has also received an order for five Francis turbines, each of 140,000 b.h.p., with a head of 282ft and a speed of 167 r.p.m., for the Kariba project.

VICKERS-ARMSTRONGS (AIRCRAFT), Ltd., has contracted to supply twenty "Vanguard" V.951, fourteen "Viscount" V.806, and two "Viscount" V.802 air liners to British European Airways. The "Vanguard," which can carry its 21,000 lb payload either as freight or passengers, will seat ninety-six people five abreast, and employ R.R. "Tyne" engines. The "Viscounts" will have R.R. "Dart" engines, R.Da.6 for the V.802 and R.Da.7 for the V.806.

PIRELLI-GENERAL CABLE WORKS, Ltd., an associate of The General Electric Company, Ltd., has obtained the contract for the manufacture in England, and the installation in Australia, of approximately 3500 yards of 330kV single-core, 0·325 square inch, copper-conductor, oil-filled, lead-sheathed cable for the T.1 power station at Cooma, of the Snowy Mountains Hydro-Electric Scheme. The cable contract includes the design and manufacture of seven 330kV single-phase cables for 340A, grouped in two three-phase circuits with one spare cable, complete with terminations, supporting structures and all ancillary equipment. They will be the first 330kV oil-filled cables manufactured in this country.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., is to supply a 12,000kW turbine-generator set to the Perak River Hydro-Electric Power Company, Ltd., for whom a similar machine is already in hand at the manufacturers' Trafford Park works. Both sets are to be installed in one of the company's thermal stations at Malim Nawar. The new sets will be generally similar to two 12,000kW sets supplied to the same customer before the war, but are for higher steam conditions. Each will have a 3000 r.p.m. single-cylinder turbine taking steam at 400 lb per square inch, 800 deg. Fah., and exhausting to condenser at a vacuum of 27·75in Hg. Three-stage feed water heating equipment will bring the final feed water temperature to 271 deg. Fah. at 12,000kW, c.m.e.r. The generators will be of standard turbo construction, air cooled and wound for 6·6kV 3 phase 50 c/s, with a power factor of 0·68 and a kVA capacity of 17,650 to enable them to be used for line charging, if required.

Miscellanea

TWO 120MW SETS AT BELVEDERE POWER STATION.—The Minister of Fuel and Power has approved the substitution, in the C.E.A. Belvedere power station, near Erith, of two 120MW turbo-generator sets for four of the eight 60MW sets authorised in June, 1954. Belvedere, which is due to begin production in 1958, is one of the C.E.A. power stations to be equipped for dual firing by oil or coal.

EXPERIMENTAL B.R. RESTAURANT BUFFET CARS.—Tests are being carried out in regular service of three experimental vehicles, built to determine the future design of British Railways restaurant and buffet cars. The new vehicles include a restaurant buffet car for use in the Eastern Region between Liverpool Street and Ely; a restaurant car for use in the Western Region between Paddington and Weston-super-Mare; and a kitchen buffet car for use in the London Midland Region between St. Pancras and Manchester Central.

LLOYD'S WRECK RETURNS.—The returns of merchant ships totally lost, broken up, &c., during the quarter ended December 31, 1955, issued by Lloyd's Register of Shipping, show that the world total of steamships and motorships lost consequent upon casualty amounted to 50 ships of 62,916 tons gross. This total included 8 ships of 9033 tons belonging to Great Britain and Northern Ireland and 7 ships of 8210 tons belonging to the Commonwealth countries. The corresponding totals for vessels lost not consequent upon casualty were 103 ships of 170,404 tons gross, 45 ships of 47,567 tons and 7 ships of 11,885 tons respectively.

NUCLEAR ENGINEERING COURSE.—A short course of ten lectures entitled "Introductory Course in Nuclear Engineering" is to be held at the Wolverhampton and Staffordshire Technical College on Friday evenings, commencing October 5, 1956. This course is primarily for engineers requiring a fundamental knowledge of nuclear energy as applied to power generation and will be followed by a more advanced course "Nuclear Engineering," commencing January, 1957. We are informed that preliminary inquiries from interested firms and individuals should be addressed to the head of the Department of Mechanical Engineering, at the college.

HELICOPTER PROGRESS.—Saunders-Roe "Skeeter" helicopters are being ordered for Air Observation Post squadrons of the Royal Air Force for tactical use with the ground forces. The "Skeeter" is a small two-seat helicopter fitted with the D.H. "Gipsy Major" 200 engine, and has a top speed of 101 m.p.h. Maximum power can be sustained for one hour, allowing prolonged hovering. A Bristol 173 twin-engined tandem rotor helicopter has been handed over to British European Airways for an extensive series of handling trials. Three more of these research aircraft are being built by Bristol Aircraft, Ltd., and will use 850 h.p. Alvis "Leonides Major" engines instead of the 520 h.p. "Leonides" of the first two. A "173" has flown from London, South Bank Terminal, to Paris, Le Bourget Airport, at an average speed of 112 m.p.h.

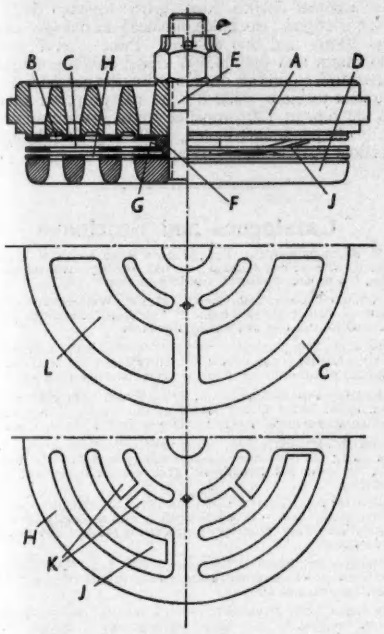
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

VALVES

752,308. October 4, 1954.—ANNULAR PLATE CHECK VALVES, Martina Hoerbiger and Johann Robert Hoerbiger, personally responsible partners of Hoerbiger and Co., 23, Braunhubergasse, Vienna XI, Austria.

An object of the invention is a spring element which simultaneously exerts a weak force on the valve plate and a more powerful force on the damping plate, and which can be accommodated also in valves of small diameter. In the drawing *A* is the valve seat, *B* the valve plate, *C* the damping plate, *D* the valve guard, *E* the central assembling screw, and *F* a guide ring with a stepped shoulder *G*. As shown in the lower view, *H*, the spring plate, is formed so as to present long up-bent blades *J* and the short spring



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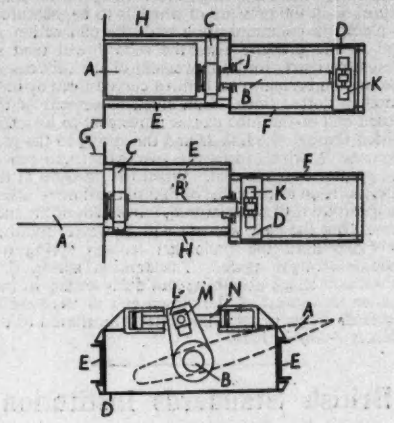
blades *K*. The centre view shows the slots *L* in the damping plate *C*. It will be seen that the long spring blades *J* of the spring plate pass through the slots *L* in the damping plate, and act directly on the valve plate *B*, while the short spring blades *K* of the spring plate press against the damping plate *C*. The long blades have a flat spring characteristic and the stiffer short blades a steep spring characteristic. A modified design is also shown in the specification in which the spring plate has, in addition to the spring blades *J*, spring tongues formed on its outer edge, which also press against the damping plate.—*July* 11, 1956.

MARINE ENGINEERING

752,744. September 29, 1954.—MEANS FOR DAMPING THE ROLLING MOVEMENT OF SHIPS, Franz August Süberkrüb, Burchardtstrasse 18, Hamburg 1, Germany.

The invention provides a device for damping the rolling movement of ships by means of extensible and retractable foils or stabilisers which are rotatably mounted on two movable transverse members, and the characteristic feature of the invention is that each foil or stabiliser is provided with a separate rotating means which is extended and retracted together with the associated stabiliser. The driving means is mounted in the movable transverse member which carries the inner bearing of the shaft for the stabiliser. Referring to the drawing, in which the two upper views show the stabiliser retracted and extended, *A* is a hydrofoil or stabiliser which is fixed to the shaft *B*. The shaft is rotatably mounted in the transverse members *C* and *D*. The transverse members are guided on guide rails *E* and *F* and are moved in and out by known means, not illustrated in the drawing. *G* is the side of the ship. A watertight box *H* encloses the stabiliser *A* and the outer transverse member *C*. The shaft *B* is guided through a stuffing box *J* into the interior of the ship. The prime mover *K* for rotating the stabiliser is mounted on the inner transverse member *D*. The lower drawing shows how the rotating means may be constructed and mounted. On the shaft *B* is fixed a lever *L*, in which a block *M* is slidable. To this block is fixed a piston-rod *N* which carries pistons which move in cylinders



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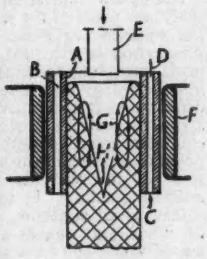
as shown. The pistons can be operated by steam, compressed air, water or other medium. The supply of the working medium is effected by means of slides or valves which can be controlled by means of a gyroscope.—*July* 11, 1956.

METALLURGY

752,271. May 17, 1954.—MOULDS FOR USE IN THE CONTINUOUS CASTING OF STEEL, Irving Rossi, 40, Wall Street, New York 5, U.S.A.

The invention has for its object improvements in moulds for the continuous casting of metals and especially steel, and makes it possible to obtain cast pieces in which the crater has been reduced to admissible sizes without decreasing the rate of casting. The mould illustrated in the drawing is formed of a vertical part *A* cooled by a circulation of fluid in the passage *B*. The fluid may be admitted at the lower part of the passage in the direction of the arrows *C* and flow out in the direction of the arrows *D*. The molten metal is introduced at the upper part of the mould through a nozzle *E*. The metal spreads in the mould and solidifies rather quickly on contact with the wall of the mould whilst it remains liquid or pasty in the centre of the mould cavity. According to the invention, there are provided around the mould induction coils *F* so energised that their magnetic field inside the mould causes a circulation of still molten metal in the direction of the arrows *G*, namely, an upward circulation near the axis of the mould and a downward circulation near the walls. The result is that the crater *H* which normally forms at the upper part of the cast piece is less deep than usual in moulds. The cooling of the metal takes place efficiently since the metallic liquid parts go up along the axis of the mould or near it to cool promptly in the proximity of the inner walls of the mould or along the already solidified metallic parts. Moreover, the upward metallic liquid stream occurring at the upper part of the cast piece reacts against the jet of liquid metal coming down through the nozzle. Finally, the mixing of the molten metal occurring in the crater and in its proximity allows the gas blisters and impurities to come up to the upper surface and either to be eliminated or removed. The danger of segregation of the metal is considerably reduced by the mixing action. A modified design is also shown in the specification.—*July* 11, 1956.



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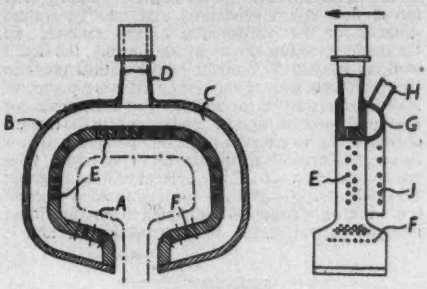
RAILWAY ENGINEERING

752,666. February 10, 1954.—THE FLAME-HARDENING OF STEEL RAILS, Naamlooze Vennootschap de Bataafsche Petroleum Maatschappij, 30 Carel van Bylandtlaan, The Hague, The Netherlands.

The object of the invention is to provide a method of hardening rails by which the heat required for tempering, i.e. effecting gradual transition from the hardened to the non-hardened zone, is supplied in an economical manner. In the drawing the head of the rail being treated is shown at *A*. The apparatus *B* used for treating the rail head and enclosing part of it comprises a chamber *C* with a conduit *D* for delivering a combustible gas mixture. The wall of this chamber facing the rail head has a number of primary burners *E* by means of which flames are directed on to the upper side and flanks of the rail head, and also a number of secondary burners *F* by means of which flames are directed on to the bottom of the rail head. As shown more clearly in



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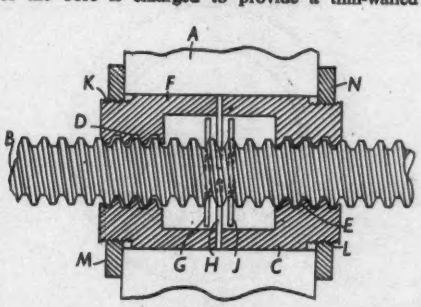
the right-hand view, the primary burners *E* are all arranged in the neighbourhood of a plane perpendicular to the longitudinal axis of the rail, while the secondary burners *F*, provided at the bottom of the gas chamber *C*, which is here enlarged in a direction parallel to the length of the rail, extend over a greater distance along the length of the rail. In addition, the apparatus also comprises a liquid chamber *G* with supply line *H* for the cooling liquid. The liquid chamber *G* is secured adjacent to the gas chamber *C* and has approximately the same shape but extends only over the upper side and the flanks of the rail head. Through the openings *J* jets of coolant are directed on to the upper side and the flanks of the rail head but not on to the bottom of the head. Since the liquid chamber *G* is in contact with the gas chamber *C* intensive cooling of the latter is also effected, resulting in a longer life of the apparatus. The apparatus shown in the drawing is moved over the rail in the direction of the arrow and it can be mounted on a carriage which runs over the rail. Instead of moving the apparatus along the stationary rail, it is also possible to move the latter and keep the apparatus stationary.—*July* 11, 1956.

MACHINE TOOLS

752,459. January 14, 1954.—ELIMINATION OF BACK-LASH IN SCREW-THREAD ASSEMBLIES, Metropolitan-Vickers Electrical Company, Ltd., St. Paul's Corner, 1–3, St. Paul's Churchyard, London, E.C.4. (*Inventors: Michael Crowley-Milling and John Marshman Stevens.*)

It is an object of the invention to provide a simple and inexpensive though efficient means for substantially eliminating backlash in lead-screw arrangements. As shown in the drawing, the assembly comprises a fixed structural part *A* with respect to which a lead-screw *B* is required to move without backlash and an intermediate cylindrical member *C* which is bored axially and threaded at each end at *D* and *E* to receive the screw. The central portion of the bore is enlarged to provide a thin-walled



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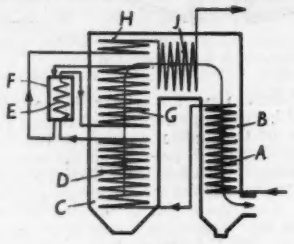
cylinder *F* which is cut through near its mid-portion by three pairs of slots *G*, *H* and *J*, extending part of the way around the circumference in staggered and spaced relationship. Thus, the member *C* is engaged by the screw *B* only towards its ends which are threaded externally at *K* and *L* to receive nuts *M* and *N*. These nuts serve to clamp the member *C* to the structural part *A* and it will be seen that by tightening the nuts there against, the member may be extended axially by virtue of the slots cut around the portion *F*. Thus, the distance between the threads *D* and *E* may be increased sufficiently to take up back-lash. In a modified form of the invention the thread and nut at one end, say *K* and *M* are replaced by an outwardly extending flange machined on the member *C*, in which case the backlash is taken up by tightening the nut at the other end.—*July* 11, 1956.

STEAM GENERATORS

752,264. March 12, 1954.—FORCED FLOW STEAM GENERATORS, Sulzer Frères, Société Anonyme, Winterthur, Switzerland.

The invention relates to forced flow steam generators of the once-through type in which the steam is generated at critical or supercritical pressure. The invention embraces a new method of operating such forced flow steam generators and new generators suitable for the performance of the method. In the steam generator shown in the drawing, the liquid working medium is brought to the critical pressure by a pump, not shown, and is then fed into a preheater *A* situated in the flue gas duct *B*. From the preheater the liquid flows into another preheater *C* in the radiant chamber *D*. It emerges from this preheater at just below the critical temperature. The liquid then passes through a tube *E* in a special heating chamber *F*, which tube contains the conversion zone wherein the working medium is converted from the liquid into the vapour state. If the working medium is



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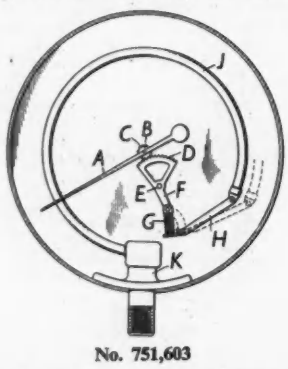
water it may enter the tube *E*, for example, at 370 deg. Cent., and the steam generated will leave the tube part *E*, for example, at 380 deg. Cent. From the conversion zone the steam flows into a superheater *G* in the radiant chamber *D*, and after leaving this superheater it is conducted in countercurrent through the heating chamber *F* for heating the tube *E*. In so doing the superheated steam gives up a part of its heat content, which is restored to it again in a superheater *H* in the radiant chamber *D*. Further superheating is then carried out in another superheater *J* which receives its heat by contact with the flue gases. The tube *E* containing the conversion zone is thus situated outside the radiant chamber *D* as well as out of contact with the flue gases, and is therefore completely withdrawn from any direct influence by the hot gases or by the radiation of the furnace, being heated indirectly with superheated steam from the same system. A modified arrangement with cooling means for the conversion zone is also shown in the specification.—*July* 11, 1956.

MEASURING INSTRUMENTS

751,603. December 31, 1953.—PRESSURE GAUGES, Blaw-Knox, Ltd., 90–94, Brompton Road, London, S.W.3. (*Inventor: Stanley Peter John Ellis.*)

According to the invention, there is provided a Bourdon gauge in which the link is connected to the gear segment through the intermediary of a coiled spring that extends transversely from the link, the



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arrangement being such that when the gauge is in use sudden movement of the closed end of the tube in either direction causes the spring to bend, whereby movement of the pointer lags behind the movement of the tube, the spring resuming its initial shape after the closed end has become stationary. The drawing shows a gauge having a base member to which a circular dial is attached, the dial carrying pressure graduations. A pointer *A* co-operates with the dial and is mounted at the centre of the dial on a shaft *B*. A gear wheel *C* fixed on the shaft co-operates with a gear segment *D* pivoted at *E* on the base member. The segment has an arm *F*, to the end of which a coil spring *G* is connected, the spring being carried by and extending laterally with respect to a link *H*. The link is pivotally connected to one end of an elliptical-sectioned tube *J* which is of arcuate form and extends around about 300 deg. of a circle. That end of the tube to which the link is pivotally connected is closed while the other end is secured to and is in open communication with a connection *K*. The spring *G* is a preloaded tension spring, in which the coils contact each other when the spring is free. In operation of the gauge, fluid, the pressure of which is to be measured, is placed in communication with the connection *K*, and as the pressure rises the tube *J* will tend to straighten itself. Initial movement of the tube causes the tension spring to be bent to curved form as indicated in dotted lines. Continued movement of the closed end of the tube causes movement to be transmitted through the link *H* and the spring to the gear segment *D*, which turns the gear wheel and moves the pointer over the dial. When the pressure in the tube has risen to the value of that of the fluid of which the pressure is to be measured, movement of the tube ceases, but the gear segment will, however, continue to move until the preloaded tension spring has become straight again. The tension spring thus serves as a shock absorbing and delay means so that sudden movement of the closed end of the tube in either direction is not immediately transferred to the pointer.—*July* 4, 1956.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

INDUSTRIAL TEMPERATURE-DETECTING ELEMENTS AND POCKETS

No. 2765 : 1956. Price 2s. 6d.—There is at present a wide divergence in the meanings attached to the descriptive terms and letter symbols in common use for thermometer elements and pockets, and this new standard aims at producing a uniformity of practice. It defines the terms relating to such elements and their protective devices and describes a dimensioning system, together with appropriate letter symbols, which may be employed in the preparation of purchasing specifications for industrial applications. The temperature-detecting elements to which this standard applies are component parts of liquid-filled, mercury-filled, gas-filled and vapour-pressure thermometers, glass-stem thermometers, and resistance, thermocouple and bimetallic thermometers.

During the preparation of this standard a careful study was made of the tentative standards issued by the American Scientific Apparatus Manufacturers' Association in this field. An endeavour has been made throughout to achieve Anglo-American accord in terminology and lettering symbols, although in deference to British practice it was considered necessary to use the term "pocket" for which the American equivalent term is "well." In due course it is proposed to prepare a British Standard for those dimensions of the elements and pockets which affect interchangeability. In the meantime B.S. 2765 includes, as an appendix, some preferred dimensions for attachment threads and attachment flanges, the use of which will be a step towards securing interchangeability of the elements as complete units.

PITCH-IMPREGNATED FIBRE DRAIN AND SEWER PIPES

No. 2760 : 1956. Price 4s.—This standard relates to pipes and fittings for drains and sewers manufactured of a material so far little used in this country. They are made of a preformed felted structure of cellulosic fibre thoroughly impregnated under vacuum and pressure with coal tar pitch or suitable bituminous compound, and the walls of such pipes are dense and homogeneous and have a smooth interior surface. These pitch-impregnated fibre pipes have been used in the United States of America and in Canada for many years and it was decided to base the new standard on the United States Commercial Standard 116/54 (first published in 1944), making only minor alterations to suit British terminology and the usual British Standard form.

The standard covers a range of pipes from 2in to 8in diameter with suitable couplings and fittings. Comprehensive tests are specified, including tests for chemical resistance; resistance to boiling water and kerosene; and flattening and crushing. Pitch-impregnated fibre adaptors are available to couple these pipes to pipes and fittings of other materials. Pending prevision being made in a Code of Practice an appendix is given which contains recommendations for the laying and jointing of the pipes.

Launches and Trial Trips

ROALD AMUNDSEN, cargo ship; built by the Forges et Chantiers de la Mediterranée for Messrs. Laboremus, Oslo; length overall 475ft, length between perpendiculars 442ft, breadth moulded 61ft 6in, depth to shelter deck 39ft 6in, draught loaded 26ft 6in (open shelter deck), 30ft (closed shelter deck), deadweight 10,500/12,500 tons, service speed 14 knots; six passengers; five holds, one 30-ton, one 10-ton and sixteen 5-ton derricks; three 200kW diesel-driven generators, one Sulzer diesel engine arranged to burn heavy fuel, 5600 h.p. at 125 r.p.m.—Trial, June.

ARABIAN GULF, oil tanker; built by the Furness Shipbuilding Company, Ltd., for Afran Transport Company, Liberia; length between perpendiculars 630ft, breadth moulded 87ft, depth moulded 45ft 6in, deadweight 32,000 tons on 34ft 2in Lloyd's summer draught, designed speed 15½ knots; thirty oil cargo tanks, one main cargo pump room, four 4500 gallons per minute turbine-driven centrifugal pumps, four 150 tons per hour stripping pumps; two 500kW, 60 c/s turbo-alternators, one 100kW diesel-driven alternator, one set of Richardsons Westgarth double-reduction geared turbines, 12,500 normal s.h.p. at 105 propeller r.p.m., 13,750 maximum s.h.p. at 108 propeller r.p.m., steam supplied at 600 lb per square inch and 850 deg. Fah. by two Foster-Wheeler "D" pattern boilers. Launch, July 10th.

JADOTVILLE, passenger and cargo liner; built by the Chantiers de l'Atlantique Penhoet Loire for the Compagnie Maritime Belge; length overall 554ft 8in, length between perpendiculars 511ft 10in, breadth moulded 69ft 11in, depth to "C" deck 40ft 4in, draught loaded 27ft 5in, deadweight 10,350 tons, displacement 19,065 tons, gross tonnage 10,900; 302 passengers; six holds, nineteen derricks including one 20-ton and one 60-ton; three 815kW turbo-generators and two 115kW diesel-driven emergency generators; one set double reduction geared C.E.M. Parsons turbines, 9500 h.p. at 100 propeller r.p.m., 12,500 h.p. at 120 propeller r.p.m., steam supplied at 615 lb per square inch and 800 deg. Fah. by three Penhoet P.41 boilers.—Trial, July.

Catalogues and Brochures

H. BRAMMER AND CO., Ltd., Hudson Road, Leeds, 9.—Leaflet dealing with colour studded vee link belting used for identifying the different sizes of standard belting.

RENOLD CHAINS, Ltd., Renold House, Wythenshawe, Manchester.—Folder giving details of "Renold" couplings manufactured to precision engineering standards.

K & L STEELFOUNDERS AND ENGINEERS, Ltd., Letchworth, Herts.—Leaflet giving details of quality controlled steel castings with the precautions taken in the manufacturing process.

HOLDEN AND BROOKE, Ltd., Sirius Works, Manchester, 2.—Descriptive leaflet giving details of the "Selfin" supersilent heating accelerator designed specifically for the heating trade.

AVELING-BARFORD, Ltd., Grantham.—Publication No. 1/43, describing and illustrating tandem rollers manufactured by this firm for home and abroad, with their application in road work surfacing.

BURTONWOOD ENGINEERING COMPANY, Ltd., Burtonwood, near Warrington, Lancs.—Brochure dealing with a range of portable Hydrovane rotary compressors, now being produced by this firm under licence.

RAGLAN ENGINEERING COMPANY (1954), Ltd., Raleigh Street, Nottingham.—Illustrative leaflet giving details of the "Little John" 3in capstan lathe.

VENESTA LTD., Plywood Division, Vintry House, Queen Street Place, London, E.C.4.—Folder dealing with "Venesta" solid core flush doors made from selected timber and moisture-controlled at all stages of manufacture.

THE RUBEROID COMPANY, Ltd., Commonwealth House, 1–19, New Oxford Street, London, W.C.1.—Bulletin giving details of three types of galvanised steel deck roof that are being added to the range produced by this company, known as types "D," "E," and "F."

YORKSHIRE SWITCHGEAR AND ENGINEERING COMPANY, Ltd., Meanwood, Leeds, 6.—Illustrative brochure describing a range of high- and medium-voltage switchgear, showing typical installations.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

INCORPORATED PLANT ENGINEERS

Mon., Sept. 3rd.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Fan Engineering," 7.30 p.m.

Tues., Sept. 4th.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, Strand, W.C.2, "The Maintenance of Lancashire and Economic Boilers," J. H. Williams, 7 p.m.

Wed., Sept. 5th.—LEICESTER BRANCH: Bell Hotel, Leicester, "Planned Maintenance," A. F. R. Stedman, 6.30 p.m.

Mon., Sept. 10th.—DUNDEE BRANCH: Mathers Hotel, Dundee, "The Application of Work Study and Incentives to Maintenance," D. Gardiner, 7.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., Oct. 11th.—Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, "Scale Effect Experiments on Victory Ships and Models," Part II, "Analysis of Wake Measurements on a Model Family and the Model Boat," D. C. Endert, Jr., J. D. van Manen, 4.45 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Oct. 11th.—The Temple, Dale Street, Liverpool, Presidential Address, W. Rose, 7 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., Oct. 19th.—39, Elmbank Crescent, Glasgow, Symposium on the Application of Low-Alloy Steels for Welded Pressure Vessels, 10 a.m.